Dispersion, diet and criteria of age of roe deer (capreolus capreolus L.) in Hamsterley forest, county Durham

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Dispersion, diet and criteria of age of roe deer (*Capreolus capreolus* L.) in Hamsterley Forest, County Durham

by

Byron A. M. Henry

being a thesis presented in the candidature for the degree of Doctor of Philosophy in the University of Durham, 1975.

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ABSTRACT

The study concerned distribution, habitat use, diet and the age of roe deer (Capreolus capreolus) from Hamsterley Forest, Co. Durham. Observation and counts of pellet groups indicated that the most used habitats were rides and clearings. Within each habitat the distribution of pellet groups was random, and in general not correlated with indices of plant type and cover density. Over the study area as a whole, the distribution of pellet groups was clumped, and generally correlated with these indices.

The mean territory size of territorial bucks was 11.2 ha., the same as mean home range size of non-territorial bucks. Mean home range size of does was 8.0 ha. in 1973 and 16.5 ha. in 1974.

The diet was studied by rumen contents and faecal analysis and a comparison of the dried weights of vegetation clipped from inside and outside exclosures. The first two methods indicated that dwarf shrubs were the most used plant group with Calluna the most important food. The third of these methods suggested that grazing pressure was light and at the sampling intensity used was unreliable for indicating diet. Faecal analysis indicated that in winter sheep (Ovis aries) ate significantly more grasses and grasslike plants and less browse than the deer.

The eruption and wear method of estimating age was generally accurate to within one year, given a knowledge of the life span of the deer. The cementum layer method appeared to be completely reliable; layering was of greater clarity in histological than in gross sections of cementum. The dry weight of the eye lens increased rapidly up to 12 months of age and then slowly up to five years. Body weight increased up to about 18 months of age but not subsequently.

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1. GENERAL INTRODUCTION

The roe deer (Capreolus capreolus) is the smallest indigenous deer in Britain. It is widely distributed throughout the country but is apparently absent from most of the Midlands, extreme south-east and south-west England and much of Wales (Carne 1974). The considerable increase in distribution in recent decades has probably been largely a result of the afforestation programmes of the Forestry Commission carried out since 1920.

The body length varies from 95 to 135 cm., shoulder height from 65 to 75 cm., and weight from 15 to 27 kg. The colour of the winter coat is grey brown and that in summer, red brown. The white rump patch is most conspicuous in winter (Van den Brink 1973). Mating occurs in August with the young being born in May or June of the following year.

The roe was widely regarded as a pest by foresters because of the browsing and fraying damage it caused in young plantations. It was later realised that it could no longer be regarded as such and that through a study of its biology the roe could, if properly managed, become an asset in the forest economy. It has therefore been only in the past 15 years that research has been conducted on the biology of the roe deer in Britain. The social behaviour of the roe buck and the influence of territorial behaviour on population regulation was studied by Cumming (1966) and later in more detail by Bramley (1970). Browsing and fraying damage was investigated by Thomson (1966), the diet by Robertson (1967) and distribution and habitat requirements by Thompson (1967) and Mishra (1971). An account of the ecology and behaviour of the roe is given in Prior (1968) but the work suffers from the absence of quantitative data. Methods of age determination have been investigated by White (1974) and Aitken (1975). Problems of management and control in woodlands were discussed by Gibson and MacArthur (1965), Bramley (1972), Lowe and Donally (1973) and Prior (1974). The reproductive physiology of the female was investigated by Short and Hay (1965, 1966) and Aitken (1974) and that of the male by Short and Mann (1966).

The seasonal distributions, habitat use and habitat preferences of roe deer and the reasons why they exhibit preferences for particular habitats and avoidance of others have not been thoroughly studied. Likewise, the various methods used to investigate these aspects of the animal's ecology and the results obtained have not been subject to critical evaluation and comparison. The only detailed food study is that of Hosey (1974) which details the seasonal variations in the diet of the roe deer in a Dorset wood. Information is required on the variation in diet of the deer with habitat, and the reliability of the various techniques used to determine diet. More detailed evaluation of the respective merits of methods of determining age is required. The objectives of the present study were to investigate the ecology of roe deer in an upland coniferous habitat. The research was conducted in Hamsterley Forest, Co. Durham and the topics studied were the distribution patterns, diet and determination of age.

2. DESCRIPTION OF THE STUDY AREA

Hamsterley Forest (Ordnance Survey Grid Ref: 0452 85) is situated in the southern part of Co. Durham, approximately 25 km. south-west of Durham City. The forest was first planted by the Forestry Commission in about 1930. Currently compartments are being thinned and felled in rotation and the total planted area is about 2800 ha. The elevation of the forest ranges from 100 m. in valley bottoms to 400 m. on the surrounding hills. The soil type in the upland areas is an acid peat underlain by clay. At lower levels boulder clay occupies the upper layer.

The study area (Figs 1 and 2) is located in the south-east corner of the forest and has an elevational range of 250 m. to 380 m. It has an eastern aspect with a slope in general of about 8°, but locally as steep as 15°. This part of the forest was chosen because it contained within a small area (213 ha.) a variety of habitat types representative of those present throughout the entire forest.

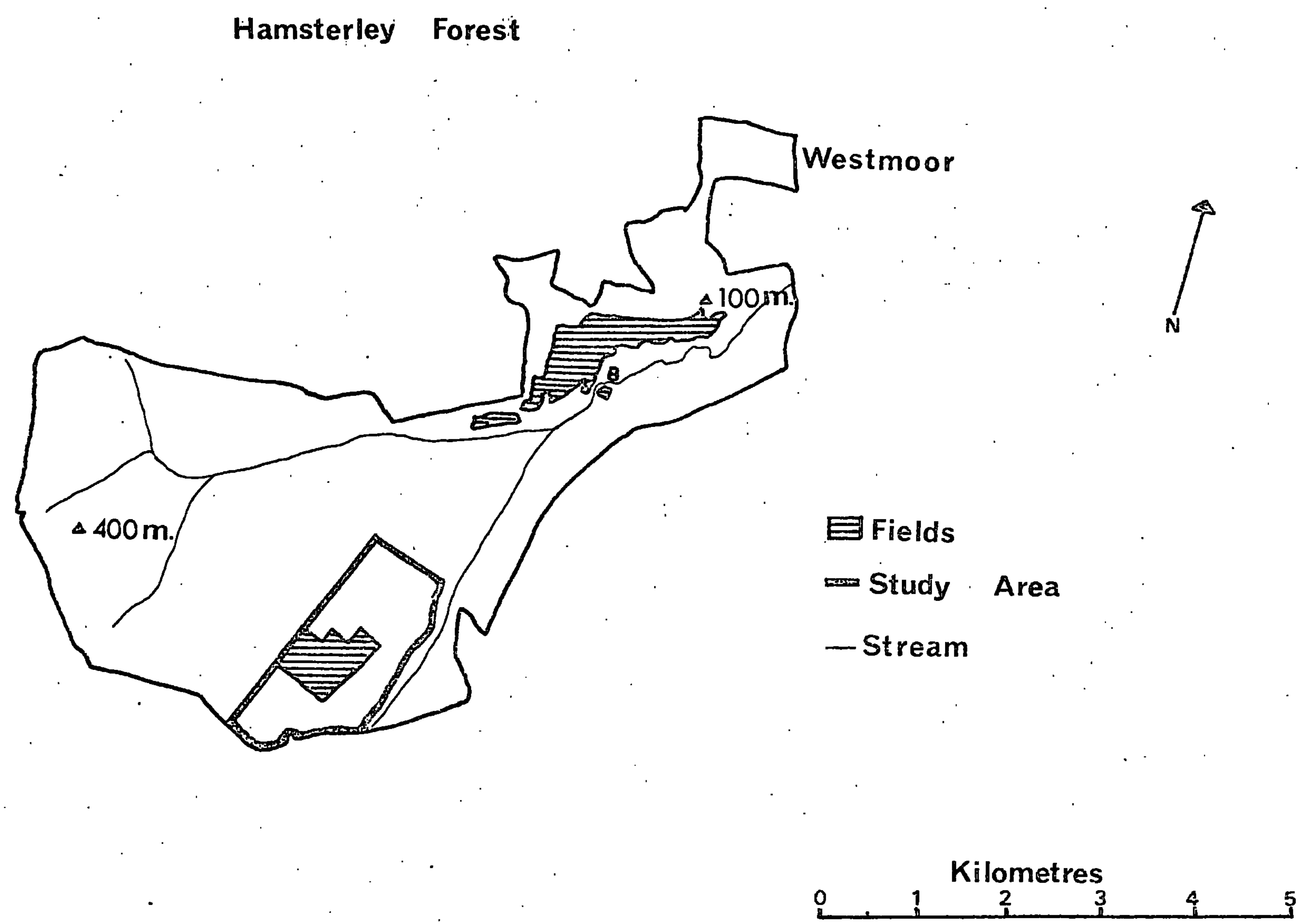
2.1 Habitat Types

Habitats were classified according to three criteria: 1. Tree species 2. Age of trees and 3. Presence or absence of ground flora. Reference was made to Forestry Commission Map No. NZ02 NW, NE, 03 SWSE. The following habitat types were recognised.

Mature Spruce

This habitat type is dominated by 35 to 40 year old sitka spruce (_Picea sitchensis_) (see Plate 1). A ground flora is absent beneath the canopy except for the occasional occurrences of mosses of which the most common are _Plagiothecium undulatum_, _Hylocomium splendens_, _Sphagnum_ sp. and _Polytrichium_ sp. _Deschampsia flexuosa_ (hair grass), _Calluna vulgaris_ (heather) and _Galium saxatile_ (heath bedstraw) are present in areas where wind blow of trees has created small openings.

Fig. 1 Hamsterley Forest, Co. Durham



Hamsterley Forest
Westmoor
100m.
400m.
B
N
Fields
Study Area
Stream
Kilometres
0
1
2
3
4
5

Fig. 2 Study Area Habitat Types

Study Area Habitat Types

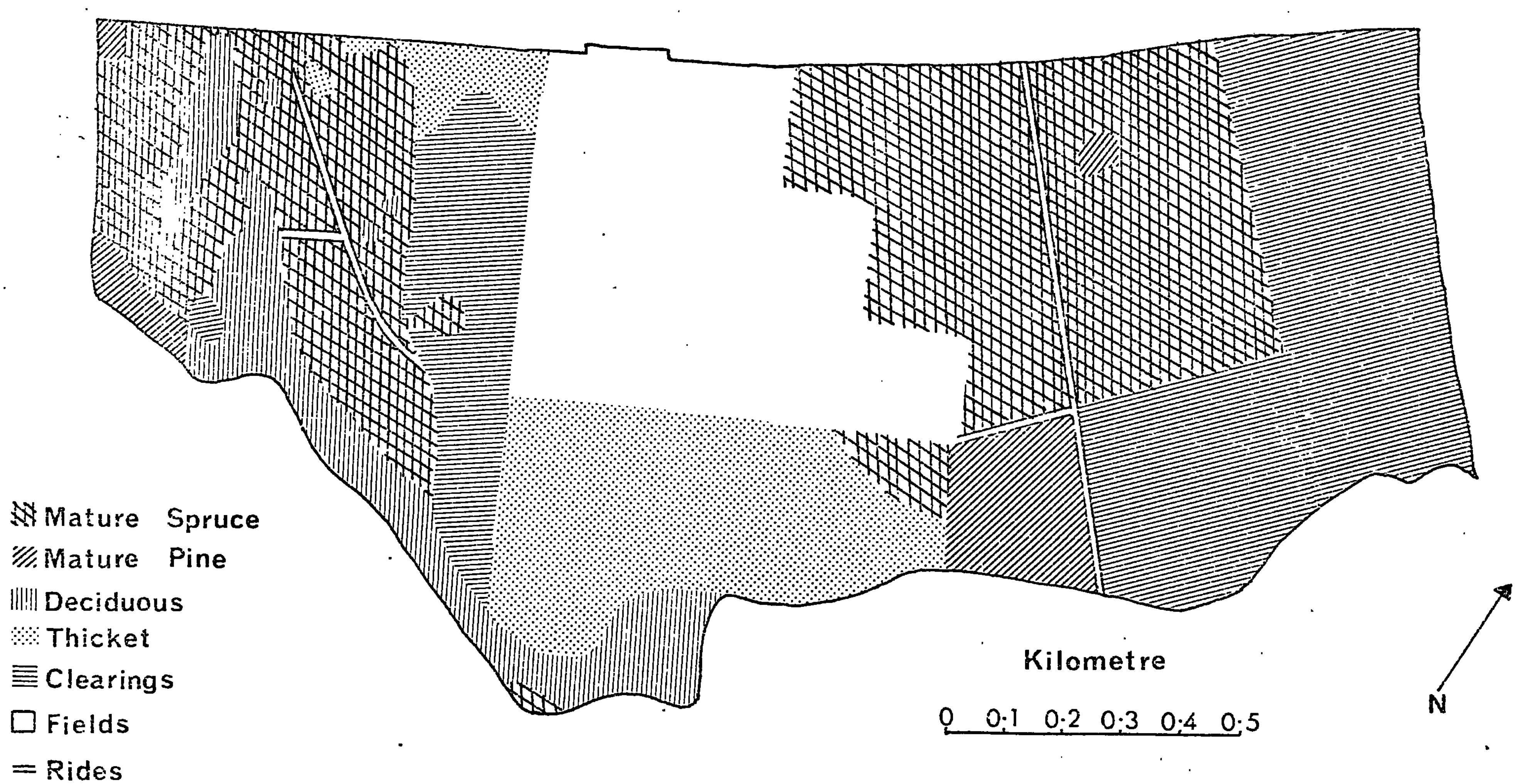


Plate 1. Mature Spruce habitat in the middle distance with clearings habitat in the foreground.

Fig. 3 a to c. Relationship of mean number of pellet groups to mean values of cover and plant type density in individual habitats in 1973.
W = Winter, Sp = Spring, S = Summer,
Au= Autumn

Grasses and Grasslike Plants

Picea sitchensis

Calluna

Cover Type	Method
A = Ground Cover	Score
B = Canopy Cover	Score
C = Horizontal Cover	Density Board

Mature Pine

This habitat type (see Plate 2) is dominated by 35 to 40 year old Pinus sylvestris (scots pine) and Pinus contorta (lodgepole pine). The ground flora is dominated by Deschampsia flexuosa and Festuca sp. (fescue). Grasslike plants are rare but Luzula sp. (wood rush) and Carex sp. (sedge) do occur. Vaccinium myrtilus (bilberry) is the most common dwarf shrub with bracken (Pteridium aquilinium) the most common fern. The most frequently occurring herbs are Galium saxatile and Oxalis acetosella (wood sorrel). Mosses present include Sphagnum sp., Polytrichium sp., Plagiothecium undulatum and Mnium hornum.

Deciduous

This habitat type (see Plate 3) includes stands consisting solely of Larix decidua (European larch) and mixed stands of naturally regenerating Betula sp. (birch), Fagus sylvatica (beech) and Fraxinus excelsior (ash). The most common dwarf shrub is Vaccinium, with Calluna occurring rarely. The common grasses are Deschampsia flexuosa, Festuca sp., Holcus sp. and Anthoxanthum odoratum. Of the grasslike plants, Carex sp. and Luzula sp. are present occasionally. Galium saxatile and Oxalis acetosella are the most frequently occurring herbaceous plants and Pteridium aquilinium is abundant in parts. Mosses occur rarely.

Plantation

This habitat type is dominated by ten and eleven year old Picea sitchensis (see Plate 4). Calluna is the dominant dwarf shrub but Erica tetralix (cross leaved heath) occurs rarely. Grasses are abundant with Agrostis sp. (bents), Deschampsia flexuosa, Deschampsia caespitosa, Festuca sp., Anthoxanthum odoratum and Holcus sp. the most important species. Carex sp., Juncus sp. (rush) and Luzula sp. occur occasionally. The most common herbs are Galium saxatile and Potentilla erecta (tormentil). Ferns present include Dryopteris sp., Pteridium aquilinium and Blechnum spicant. Common mosses are Sphagnum sp. and Polytrichium sp.

Plate 2. Mature Pine habitat. Note the growth of *Pteridium aquilinium*.

Plate 3. Deciduous habitat illustrated by *Larix decidua* with a ground flora of grasses and *Pteridium aquilinium*.

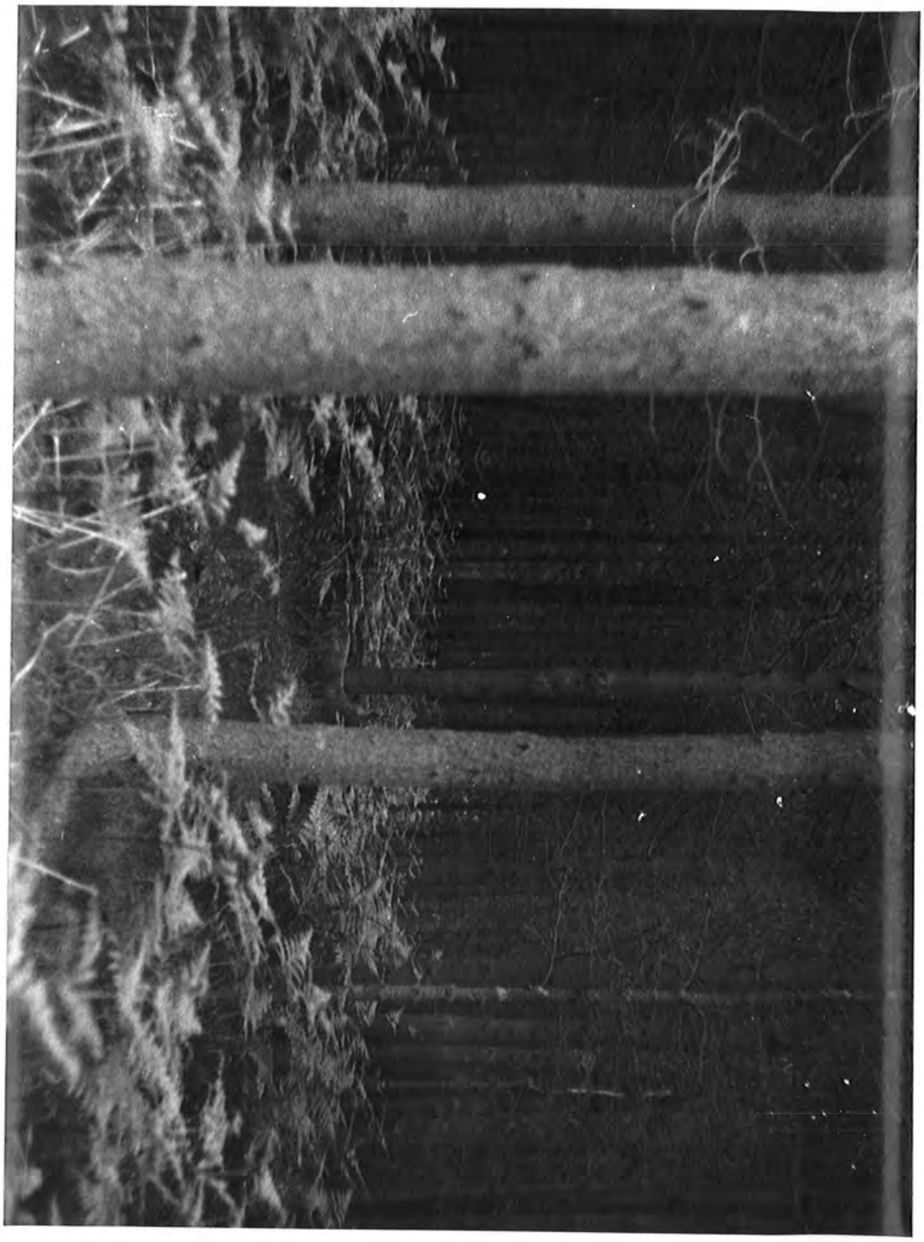


Plate 4. Plantation habitat. The trees are 10 year old *Picea sitchensis*. Note the ground flora of grasses and grasslike plants.

Clearings

These areas (see Plate 5) had been clear felled in the late 1960's and replanted in 1969 with Picea sitchensis, and in one small part with Norway spruce (Picea abies). Calluna is the dominant dwarf shrub with Vaccinium occurring very occasionally. Common grasses include Agrostis sp., Festuca sp. and Deschampsia flexuosa. Grasslike plants present are Eriophorum vaginatum, Luzula sp., Juncus sp. and Carex sp. Galium saxatile is the commonest herb but Chamaenerion angustifolium (rose-bay willow herb), Urtica dioica (stinging nettle) and Trifolium sp. (clover) are also present. Ferns present include Pteridium aquilinium and Dryopteris sp. Mosses occurring are Sphagnum sp. and Polytrichium sp.

Rides

This is recognised as a separate habitat between compartments of mature trees only; no trees are present but a substantial ground flora occurs (see Plate 6). Rides could not be distinguished within compartments of plantation stage trees or clearings since the trees in these areas are of insufficient height to cause major differences in the ground vegetation required for rides to be recognised. Calluna is the dominant plant. Grasses present include Deschampsia flexuosa, Festuca sp. and Agrostis sp. Grasslike plants occurring are Eriophorum vaginatum, Juncus sp. and Carex sp. Herbs present include Galium saxatile and Potentilla erecta. Ferns occur occasionally with Pteridium aquilinium the most common. Of the mosses, Sphagnum sp. and Polytrichium sp. are the most frequently occurring.

Fields

Grasses are abundant in this habitat type and include Festuca sp., Holcus sp., Deschampsia flexuosa, Poa sp., Anthoxanthum odoratum and Nardus stricta. Of the grasslike plants, Juncus sp. is the most important but Carex sp. and Luzula sp. occur occasionally. The most frequently occurring herb is Trifolium sp. (clovers) but Ranunculus sp. (buttercup), Rumex sp. (dock), Potentilla erecta, Galium saxatile and Onopordon sp. (thistle) are

Plate 5. Clearings habitat. Note the dense piles of brash and grasses and grasslike plants. _Picea sitchensis_ is visible in the middle distance and background.

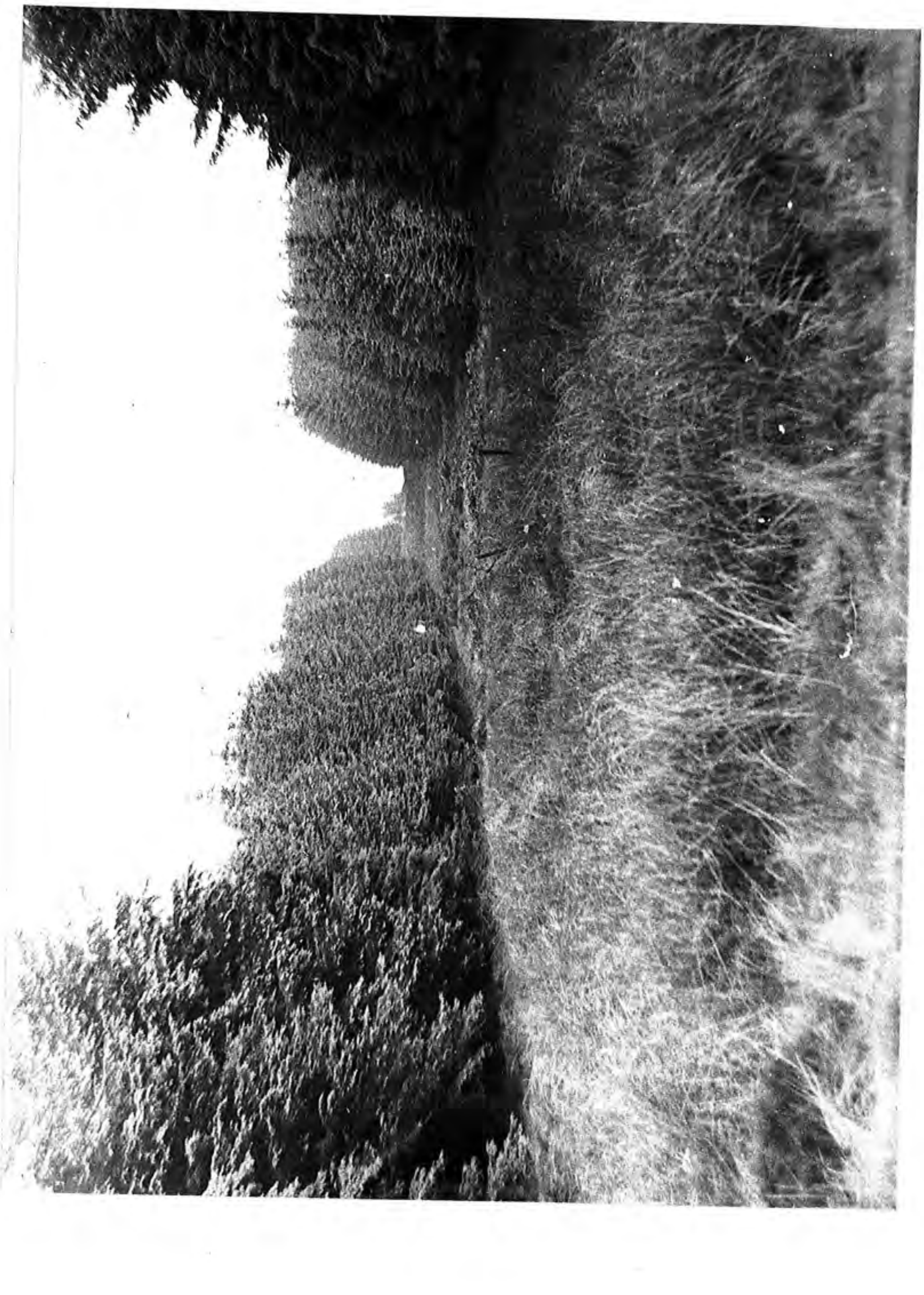


Plate 6. Rides habitat separating two compartments of mature *Picea sitchensis*. *Juncus* sp. are visible in the foreground with *Calluna vulgaris*, *Ulex europaeus* and grasses and grasslike plants in the middle distance and background.

also present. Mosses present include Sphagnum sp., Polytrichium sp. and Rhytidiadelphus squarrosus. Vaccinium and Calluna occur rarely.

2.2 Climate

Meteorological data were unobtainable for Hamsterley Forest and so I have used those from both Durham University Observatory and Moor House National Nature Reserve, Westmorland to provide an indication of the climatic conditions at Hamsterley. Durham Observatory is located 100 m. above sea level and is 25 km. northeast of Hamsterley Forest. Moor House has an elevational range of 300 m. to 880 m., with its observatory at an altitude of about 550 m., and is situated 40 km. east of Hamsterley. The Forest has an elevational range of 100 m. to 400 m. The following meteorological data are given for 1973 only since this was the year when almost all of the fieldwork was carried out. At Durham the mean daily temperature in January was 3.9°C, in February 4.7°C, in July 14.8°C, in August 14.4°C, and the mean monthly was 8.6°C.[1] At Moor House the corresponding values were 0.9°C, -0.1°C, 11.2°C, 11.3°C and the mean monthly was 5.2°C.[2] Total rainfall for the year was 503.0 mm. at Durham, 1485.0 mm. at Moor House and for both areas these values were less than the long term average. At Durham snow fell on 16 days and there were 116 days with ground frost, whereas at Moor House the corresponding figures were 61 days and 196 days respectively. The mean monthly wind speed at Durham was 19.4 km/h. but 23.0 km/h. at Moor House. Since Hamsterley is approximately one third the distance from Durham to Moor House and the mean altitude rather below the mid point between that of Durham and Moor House, it can be assumed that the values at Hamsterley will have been about midway between those of the two stations.

1. Data from Durham University Observatory, Daily Meteorological Observations 1973.

2. Data from Rawes, M. 1974. 15th Annual Progress Report. The Nature Conservancy Council, Moor House.

3. DISTRIBUTION AND HABITAT USE RELATED TO PLANT AVAILABILITY AND COVER DENSITY

3.1 Introduction

The determination of the habitat preferences of roe deer is basic to an understanding of the animal's ecology and to its management. The main methods used in such work are counts of faecal pellet groups and observation of the behaviour and location of individuals and groups.

Counts of pellet groups have been used to determine the distribution patterns of cervids in North America (White 1960, Julander 1966, McCaffery and Creed 1966, McMahon and Inglis 1974), in New Zealand (Riney 1957) and in Britain (Batchelor 1960, Thompson 1967, Holloway 1967 and Jackson 1974). However, the extent to which pellet group distribution patterns are valid as indicators to habitat preferences is uncertain owing to lack of study of the relationship between defecation and other deer activities. McMahon and Inglis (1974) have reported that comparisons of pellet group counts between seasons cannot be used to show changes in the degree of use of given habitats with season because of seasonal differences in defecation rates. However, Neff (1968) stated that counts of faecal groups can be used to indicate population trend between years or between areas without knowing to what extent defecation rate changes with season. It is necessary to assume only that defecation rates are similar at a given season in all years and areas. Julander (1966) stated that *Odocoileus hemionus* usually defecate where they feed and seldom at bed sites. Results obtained from observation have in some cases supported those from pellet group counts (White 1960, Loveless 1967, Henry 1972), whereas in others they have disagreed with them (Leckenby 1968 from Anderson, Medin and Bowden 1972a).

Dasmann (1971) has stated that food, cover and water are the main factors influencing deer distribution and choice of habitat. Thompson (1967) found a relationship between the distribution of roe deer and habitat factors, in particular the availability of browse, the nature of ground vegetation and degree of cover. Anderson et al (1972a), working on the winter range of Odocoileus hemionus, attempted correlation analysis of the frequency distribution of counts of pellet groups and 32 abiotic and biotic site factors measured on pellet group plots. The distribution of pellet group numbers was closely correlated with the distribution of vegetation and with the density of the main winter food. However, deer numbers were not correlated with the production and use of this main winter food and of another important winter food (Anderson et al 1972b).

Observation has been widely used to determine habitat preferences (Allen 1968, Miller 1968, Nixon, Milford, McClain and Russell 1970) and the activities of deer in North America (Montgomery 1963, Michael 1970) and to a limited extent, those of roe deer in Europe (Strandgaard 1972) and in Britain (Bramley 1970). Most workers make their observations in the early morning and evening, with some also making midday observations. A few workers have made night time as well as day time observations (Michael 1970, Strandgaard 1972), but the sighting of deer at night is difficult, given the much reduced visibility.

Observation is the only method for determining the size of home range and of territory of large mammals, with the exception of location by tracking in snow (Mottl 1957), or by radio-telemetry. Several studies have reported on the home range and territory sizes of roe deer in Europe (Van Mottl 1957, Strandgaard 1972) and in Britain (Cumming 1966, Bramley 1972 and Hosey 1974).

Territorial behaviour in roe deer limits the number of bucks in an area by causing emigration of young males (Bramley 1970, Strandgaard 1972). Because of this territorial system and the fact that does occupy a home range which overlaps territories, the number of does using parts of a given territory varies, being dependent upon that part of the home range with the best feeding (Strandgaard 1972). Consequently home range size may be related to the food supply (Strandgaard 1972). Territories are also reported to contain an adequate food supply (Bramley 1970). In Lagopus scoticus (red grouse), the males contest annually for territories in the autumn with the result that those cocks which do not obtain or retain a territory are forced to emigrate (Jenkins Watson and Miller 1963). The number of cocks holding territories and of hens pairing with them limits the number of breeding birds in the following spring (Watson and Jenkins 1968). This number of breeding birds is also dependent on the number of territories an area can support which is dependent upon territory size. Mean territory size is inversely correlated with the spring population density, but a more important factor influencing territory size is aggression (Watson and Miller 1971). In Parus major (great tit), territorial behaviour limits breeding density in optimal habitats only. Differences in territory size are apparently due to social interactions amongst the birds and not to food supply or other environmental resources (Krebs 1970).

The aims in the present study were to compare counts of pellet groups and observation as methods of determining habitat preferences; to relate counts of pellet groups to indices of plant type availability and density of cover; and finally to estimate and compare home range and territory sizes of the deer living in the coniferous habitats at Hamsterley with those recorded from other parts of Britain.

3.2 Methods

3.2.1 Counts of Pellet Groups[1]

Small rectangular plots 25 m. x 2 m. were used as they can be easily searched, which contributes to increased sampling efficiency (Neff 1968). In order to estimate the optimum number of plots required to sample the entire study area, a preliminary pellet group survey was carried out. In this survey, two plots were located in each of the mature spruce and the clearings habitat types as these types occupied between them a little over

[1] Deer faecal pellets were generally of small size and oval in shape relative to those of sheep which were larger, round in shape and with the pellets often adhering in clumps.

half the study area, and one plot in each of the rides, plantation, mature pine and deciduous habitats.

Each plot in the preliminary survey was randomly located by walking 100 m. into each habitat in a direction determined by the second hand of a watch. At the 100 m. point, sampling was conducted on a 25 m. x 2 m. plot, the direction of the long axis of which was likewise determined from the watch second hand. This random sampling procedure is hereafter referred to as the watch method. The criterion for a pellet group was a collection of 20 or more pellets (Henry 1972) or a continuous trail of the same which could have been dropped by a moving deer. Fifty percent of a pellet group located on a plot boundary had to be within the plot to be counted as one group. The data obtained from the preliminary survey were:

Number of plots		= 8
Total number of pellet groups		= 15
Mean " " " "	per plot $\bar{x}$	= 1.87
Variance s^2		= 0.67

According to the formula given by Neff (1968), the total number of plots (N) required was:

$$N = \frac{s^2 \times t^2}{(d \times \bar{x})^2}$$

At P = 0.05, t = 2.36 for 8-1 d.f. At this level of probability, the total number of plots required for a designated accuracy (d) of $\bar{x}$ of 10% proved to be 110.

The number of plots located in each habitat was made proportional to the percentage area occupied by each habitat type, with a minimum of five for the two habitats covering only a small proportion of the total area.

Habitat Type	% of Study Area	Estimated number of plots required	Actual number of plots established
Mature Spruce	31	34	34
Mature Pine	2	2	6
Deciduous	7	8	12
Plantation	13	15	18
Clearings	27	30	30
Rides	1	1	5
Fields	19	20	18
(Total)		110	123

Plots were located randomly in the rides habitat using the watch method because of the small proportion of the total area which the rides covered. In each other habitat, plots were systematically located at 75 m. intervals along transect lines which were perpendicular to the contours (see Appendix Fig. 1). The distance between transect lines varied. It was dependent upon the area and the distribution of the habitat and the number of plots to be located. All pellet groups were removed from the plots when plots were first established in December 1972. Winter, spring, summer and autumn distribution and habitat use by deer were determined from pellet group counts at the end of March, June, September and December 1973.

Pellet group counts are usually made at the end of winter only because of the difficulty of finding pellet groups in the growing season through the ground being obscured by vegetation. In this study it was felt justifiable to make counts in all seasons, given very thorough searches of all plots with long grass and _Pteridium_ in June and September and on those plots with _Calluna_ at all times.

3.2.2 Estimation of Plant Availability and Cover Density

Plant availability was measured by visual estimation of the percentage area of ground covered by possible food plants namely, grasses and grasslike plants, _Calluna_ and _Picea sitchensis_. In the last mentioned, availability included growth up to a height of 1.23 m. The scale of availability used was a modification by DeVos and Mosby (1969) of that devised by Aldous

(1944) to estimate density of available browse. The scale used in the present study had a base estimate of 5% (rare) rising to a maximum of 95% (dominant) in increments of 10%.

Two methods were used to measure density of ground cover: the Wight Density Board method (DeVos and Mosby 1969) and a qualitative score method based on Thomson (1966). The Wight Density board is 1.84 m. high with each 30 cm. marked off and numbered from one, at the bottom, to six at the top. The board was used by being placed at one end of each plot and reading from the other end, from directly in front of the board and one metre to the left, the figures which were unobscured by cover. The mean of these two readings was taken as the measure of cover; zero cover gave a reading of 21 (1+2+3....+6), whereas with the board totally obscured, the reading was zero. Hence a measure of the visual obstruction or density of cover was indicated. The basic criterion for using the score method was all vegetation up to a height of 1.23m., since cover this high is sufficient to completely hide a deer. Plant growth of this height would be classified as tall with that classed as moderate and low being proportionately shorter.

		Ground Cover		
Quality:	None	Low	Moderate	Tall
Score:	0	1	2	3

Estimation of canopy cover was also based on a qualitative score procedure. Using this method, all growth above 1.23 m. was classified

		Canopy Cover		
Quality:	None	Scarce	Moderate	Dense
Cover:	0	1	2	3

as canopy. For example, a mature deciduous canopy in winter could be classified as scarce since leaves are absent, but in summer when the latter are present the same canopy could be classified as dense.

In dense or tall cover the score method provides a high score whereas the density board reading would be low. Since the two methods provide converse results, care in interpreting these is required. For example, a negative relationship between density board cover estimates and indices of deer use in an area would indicate that the highest level of deer use of the area was associated with maximum density of ground cover, whereas the opposite result would be indicated if cover estimates based on the score method were related to the deer usage indices.

3.2.3 Observation of Individuals

Observations were made in each month of 1973 and from April to July 1974 using 7 x 35 mm. binoculars from a vehicle on forest roads or during walks through the study area. They were made between 6 a.m. to 9.30 a.m. in the mornings and from 5 p.m. to 10 p.m. in the evenings during late spring and summer; from 7.30 a.m. to 10 a.m. in the mornings in early autumn, and from 8 a.m. to noon at all other times of the year. Each time a deer was observed, its sex, behaviour, habitat type where located, and age group based on body size, and also degree of antler development in males, were noted. A deer was classed as a kid if under six months of age; as a yearling from six months to 18 months of age. Adults were over 18 months of age. All observations were plotted on maps of scale 1 cm. = 0.1 km. The number of hours spent observing in each month was also recorded.

3.2.4 Estimation of Territory and Home Range Size

Territory refers to a defended area which in roe deer is held by a mature buck (Bramley 1971). Juvenile bucks and does of all ages do not defend the area they occupy which is therefore referred to as a home range.

Estimation of territory and home range size is dependent upon the ability to identify individuals. The only marking technique permitted by the Forestry Commission in the Hamsterley area was the self-attaching collar method (Verme 1962). The collars were made from strips of coloured plastic (Dalton Marker Straps) and had flashs made from differently coloured plastic tape stuck onto either side. From March to May 1974, about 50 self-attaching collars were located on selected deer paths throughout the study area.[1] In addition, kids captured within a few days of birth were tagged in one ear with a large numbered plastic ear tag.

Some individual deer could be identified from natural markings and antler characteristics: does as individuals by scars and pelage, individual non-territorial bucks by their small body size, 'buttons', hard spiked antlers or more often by their spiked, sometimes slightly forked, velvet antlers. Adult bucks which were non-territorial were so recognised by their retiring, submissive behaviour, tendency to carry their heads low and distinguished individually by their antler conformation. Territorial bucks were distinguished by their bearing, behaviour, large size and identified individually by their antler conformation. Furthermore, the antlers of territorial bucks had already shed the 'velvet' in late February or March. This was some weeks before it was lost by non-territorial adult bucks and some months before its loss in non-territorial yearling bucks.

Sketches were made of the antler form of all bucks. When an individually recognisable deer was observed, the location was noted on a map of scale 1 cm = 0.1 km. The area of the territory or home range during the period of territorial behaviour from March to August (Bramley 1970) was estimated by the polygon method. This involves joining the outermost locations of sightings by straight lines and measuring the area thus enclosed.

3.2.5 Outline of Statistical Tests Used

Sokol and Rohlf (1969) is the reference text for all statistical tests used, unless otherwise stated.

It was necessary to compare the frequency distributions of numbers of pellet groups per plot in individual habitats in each season, with the Poisson distribution in case the data required transformation for analysis

1. See Appendix 5.

of variance (anova). This was done using the coefficient of dispersion index and chi-square (Southwood 1968). It was found that all frequency distributions, except one which was clumped, were of the Poisson type (see section 3.3.1 and Appendix 2). The numbers of pellet groups per plot for all habitats were then transformed using square roots $(\sqrt{x+\frac{1}{2}})$ so that a single classification anova could be carried out. Although square root transformation of clumped data is not strictly valid, even if such data after transformation only approximate to a normal distribution, the parametric anova can still be used. An alternative analysis which avoids transformation is the non-parametric Kruskal-Wallis single classification anova by ranks (see Appendix 4). Multiple comparisons tests of significance among means were based on the a posteriori Student-Neumann-Keuls (SNK) test. All multiple comparisons tests were made at the 5% level of significance only because comparisons at another level of significance would entail duplication of all tables which show multiple comparisons analyses. Classifications of all pellet group data under habitat types and seasons were considered as fixed effects as opposed to random effects.

Correlation analysis was conducted using the non-parametric Spearmann coefficient of rank correlation. This method can be used when the data are known not to be bivariate normally distributed and when the variables being tested are not susceptible to accurate measurement (Parker 1973).

3.3 Results

3.3.1 Counts of Pellet Groups as an Index of Distribution and Habitat Use.

The total number of pellet groups counted on all plots for each season was: winter 111, spring 89, summer 108 and autumn 110. The fitting of the frequency distribution of counts of pellet groups per plot to the Poisson indicated random distributions in individual habitats in each season, with the exception of the plantation in winter when pellet groups were clumped (see Appendix 2). The distribution of pellet groups over the entire study area was random in summer but clumped in each of the remaining seasons. No counts of pellet groups were made in the fields in any season. This was because about one month before the winter pellet group count was made, someone removed the pellet group plot markers. Re-location of the plots was not carried out as the markers might be removed again. In addition, during walks in the fields in winter I never found deer faeces. This was taken to be evidence indicating little or no deer activity in this habitat. I therefore decided to rely on observation alone to indicate use of this area.

The number of pellet groups per 100 m^2 of sampled habitat for each season is given in Table 1. During each season, the rides were the most heavily used habitat, with the clearings and plantation the second and third most heavily used respectively, except in autumn when the plantation was more heavily used than the clearings. The mature pine was used to a greater extent than the mature spruce and deciduous types. Analysis of these data using a single classification anova indicated significant

Table 1. Number of pellet groups per 100 m^2 of habitat in each season.

Habitat Type	Sampled Area m^2	Seasons Winter No. per 100 m^2	Spring No. per 100 m^2	Summer No. per 100 m^2	Autumn No. per 100 m^2
Mature Spruce	1700	1.1 (19)[a]	1.1 (19)	0.8 (13)	1.0 (18)
Mature Pine	300	2.0 (6)	1.0 (3)	1.0 (3)	1.7 (5)
Deciduous	600	0.3 (2)	0.3 (2)	0.8 (5)	0.5 (3)
Plantation	900[b]	2.3 (21)	1.8 (16)	2.9 (26)	3.4 (27)
Clearings	1500	3.3 (50)	2.4 (36)	3.1 (47)	2.9 (44)
Rides	250	5.2 (13)	5.2 (13)	5.6 (14)	5.2 (13)

[a] Number of pellet groups in sampled area.

[b] 800m^2 in autumn.

differences ($P < 0.01$) in the number of pellet groups among habitats within each season (see Table 2).

Table 2. Single classification anova of counts of pellet groups in each season among habitats.

Source of Variation	d.f.	S.S.	M.S.	F_s
Winter				
Among habitats	5	5.87	1.17	6.86[1]
Within habitats	99	16.93	0.17	
Total	104			
Spring				
Among habitats	5	3.86	0.77	5.41[1]
Within habitats	99	14.13	0.14	
Total	104			
Summer				
Among habitats	5	7.44	1.48	12.15[1]
Within habitats	99	12.12	0.12	
Total	104			
Autumn				
Among habitats	5	6.63	1.32	8.58[1]
Within habitats	97	15.28	0.15	
Total	102			

[1] Significant at P = 0.01

The SNK test was used to show among which habitats differences in the mean number of pellet groups were significant, within seasons (see Table 3). These tests indicate that in the rides the mean was significantly different (P < 0.05) from the mean in each of the other habitats in each season, except for the clearings in autumn. The mean for the clearings was significantly different from the same in the deciduous during each season, from the mature pine in summer and mature spruce in winter, summer and autumn. For habitats ranked one to four in winter and spring and those ranked one to three in summer and autumn, differences were not significant (P > 0.05).

The influence of season on pellet group numbers in each habitat was tested using a single classification anova (see Table 4). It was found that season did not have a significant influence (P > 0.05) on pellet group numbers in an individual habitat. No SNK tests were carried out as the overall anovas were not significant.

Table 3. Multiple comparisons of the mean number of pellet groups per plot in each habitat in each season.

Winter

Habitat Type:	Deciduous	Mature Spruce	Mature Pine	Plantation	Clearings	Rides
Rank:	1	2	3	4	5	6
Mean:	0.79	0.98	1.16	1.18	1.38	1.72

Spring

Habitat Type:	Deciduous	Mature Pine	Mature Spruce	Plantation	Clearings	Rides
Rank:	1	2	3	4	5	6
Mean:	0.79	0.97	0.98	1.12	1.23	1.68

Summer

Habitat Type:	Mature Spruce	Deciduous	Mature Pine	Plantation	Clearings	Rides
Rank:	1	2	3	4	5	6
Mean:	0.89	0.91	0.97	1.36	1.38	1.80

Autumn

Habitat Type:	Deciduous	Mature Spruce	Mature Pine	Clearings	Plantation	Rides
Rank:	1	2	3	4	5	6
Mean:	0.84	0.94	1.11	1.33	1.42	1.75

Differences not significant at P = 0.05 are underlined

Table 4. Single classification anova of counts of pellet groups in each habitat with season.

Source of Variation	d.f.	S.S.	M.S.	F_s.[1]
Mature Spruce				
Among seasons	3	0.15	0.05	0.46[1]
Within seasons	132	14.88	0.11	
Total	135			
Mature Pine				
Among seasons	3	0.18	0.05	0.51[1]
Within seasons	20	2.32	0.11	
Total	23			
Deciduous				
Among seasons	3	0.11	0.03	0.60[1]
Within seasons	44	2.57	0.05	
Total	47			
Plantation				
Among seasons	3	1.08	0.36	1.99[1]
Within seasons	66	11.91	0.18	
Total	69			
Clearings				
Among seasons	3	0.46	0.15	0.71[1]
Within seasons	116	24.98	0.21	
Total	119			
Rides				
Among seasons	3	0.04	0.01	0.09[1]
Within seasons	16	2.63	0.16	
Total	19			

[1] Not significant at P = 0.05

3.3.2 Distribution of the Seasonal Total Number of Observations as an Index of Habitat Use and Preference

Observations in the study area were subject to biases caused by observer disturbance and variation in visibility within habitats. These biases could not be eliminated and the data in Table 5 are considered with this in mind. Monthly habitat preferences could not be determined since the total number of observations for each month was small (see Appendix 9). Therefore, the monthly data have been pooled into seasons, and habitat preferences determined on a seasonal basis with the same months comprising each season of 1973 as comprised the seasonal pellet group data. The preference ratios employed in Table 5, assume a proportional relationship between the area of a habitat and its importance to deer, although such an assumption is not strictly valid because area is not the only component of a habitat. However, the relationship so derived does provide a useful index of relative habitat preference.

Over half of all observations in each season, except spring 1974, were made in the clearings, a result produced partly by visibility being much better in this habitat than in any other. The percentage of observations in the mature spruce in each season except autumn 1973 and spring 1974, was large considering the poor visibility within this habitat and the noise caused by cracking sticks when walking through it. The percentage of observations in each of the remaining habitats amounted to less than 10% of the total in any season, except for the plantation in spring 1974; even so in each season, maximum habitat preference was for the rides followed by the clearings and mature pine types respectively. Deer use of the plantation and deciduous habitats was proportional to their availabilities only in spring. Those habitats which were apparently unimportant to the deer were the mature spruce, plantation, deciduous and fields. The data indicate a non-random distribution of deer in the study area as a whole.

Table 5. Percentage seasonal distribution of observations and habitat preferences.

Habitat Type	Winter		1973 Spring		Summer		Autumn		1974 Spring	
	SEASONS									
	%	P[a]	%	P	%	P	%	P	%	P
Mature Spruce(31)[b]	22.7	0.7	25.4	0.8	20.9	0.7	13.9	0.4	11.4	0.4
Mature Pine(2)	2.3	1.1	2.2	1.1	3.1	1.5	6.3	3.1	2.4	1.2
Deciduous(7)	6.1	0.8	7.6	1.0	2.1	0.3	3.9	0.5	5.9	0.8
Plantation(13)	7.2	0.5	9.6	0.7	5.2	0.4	6.3	0.5	13.5	1.0
Clearings(27)	53.4	2.0	49.4	1.8	63.4	2.3	64.5	2.4	63.5	2.3
Rides(1)	8.3	8.3	5.7	5.7	5.2	5.2	5.1	5.1	3.2	3.2
Fields(19)	0	0	0	0	0	0	0	0	0	0
Total No. of observations	264		405		287		237		384	
Total hours observing	283		234		115		126		155	

[a] Habitat Preference = % of observations in habitat type/% area occupied by habitat type. Values greater than 1.0 indicate preference; values less than 1.0 indicate avoidance.

[b] Area of habitat type as a % of total for study area.

3.3.3 Relationship of Counts of Pellet Groups to Plant Availability and Cover Density in Individual Habitat Types.

The relationship of the mean number of pellet groups per plot with mean values of individual site factors for individual habitat types during each season is shown in Fig. 3, a to f. Details of these data are given in Appendices 1 and 4. Coefficients of rank correlation (r_s) of counts of pellet groups with the percentage density of plant types could be computed only for those habitats where the plant type occurred. For example, in the mature spruce habitat, rank correlation coefficients were not calculated for numbers of pellet groups with density of grasses and grasslike plants, since this plant group was not available within it (see Fig. 3a). In the following text the term variable refers to changes between seasons from positive to negative rank correlation and vice versa, for counts of faecal groups with another factor.

In the mature spruce habitat, numbers of pellet groups were low in all seasons (Fig. 3a). Canopy cover was constant throughout the year as was the density board measurement of ground cover. Pellet groups were significantly ($P < 0.05$) inversely associated with ground cover in winter only: there was no apparent relationship between these two factors in the remaining seasons. No attempt was made to correlate numbers of faecal groups with the score method estimates of ground cover in this habitat because of the absence of herbs, grasses and dwarf shrubs which normally comprise the ground cover. Numbers of pellet groups were significantly positively rank correlated ($P < 0.05$; $P < 0.01$ in spring) with canopy cover in all seasons (Table 10).

In the deciduous, fewer pellet groups were found per unit area than in any other habitat. The score and density board methods indicated that ground and canopy cover increased during the spring and decreased in summer and autumn. Pellet group numbers were significantly ($P < 0.05$) rank correlated with density board estimates of ground cover only in winter (Table 9), but significantly correlated ($P < 0.05$; $P < 0.01$ in winter)

Fig. 3 a to c. Relationship of mean number of pellet groups to mean values of cover and plant type density in individual habitats in 1973.
W = Winter, Sp = Spring, S = Summer,
Au = Autumn

Grasses and Grasslike Plants

Picea sitchensis

Calluna

Cover Type	Method
A = Ground Cover	Score
B = Canopy Cover	Score
C = Horizontal Cover	Density Board

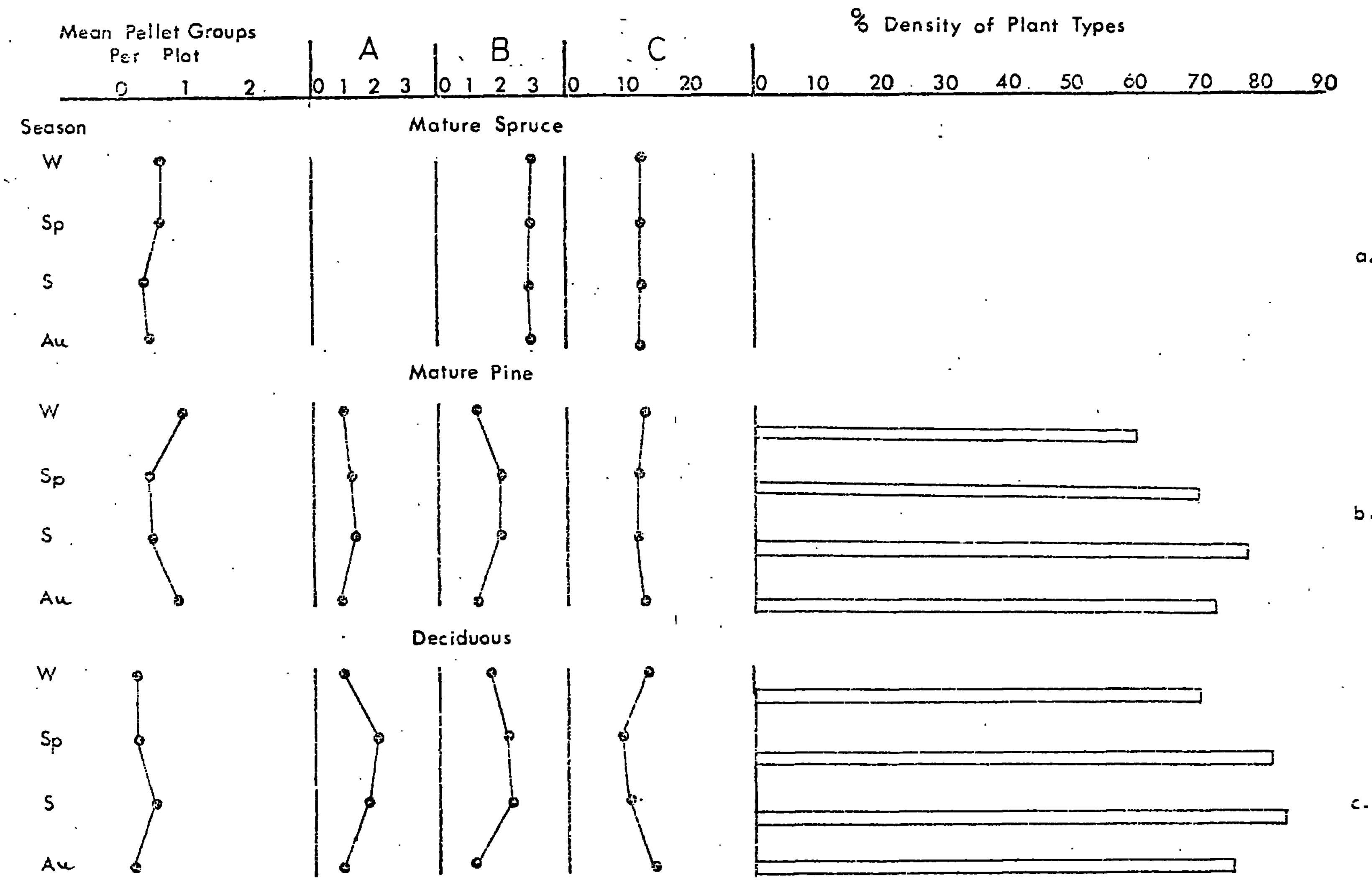
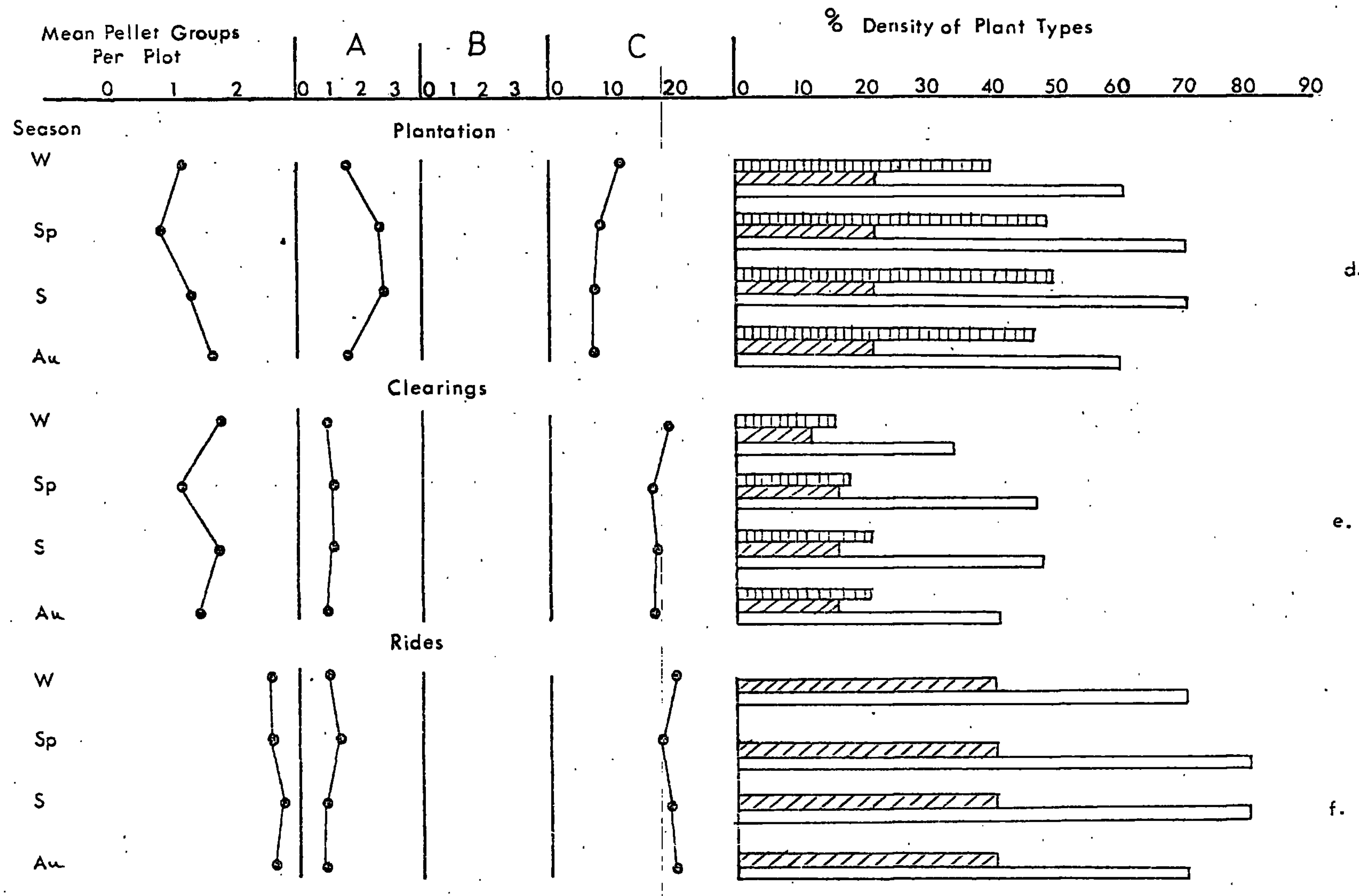

Mean Pellet Groups
Per Plot
0
1
2
A
0 1 2 3
B
0 1 2 3
C
0
10
20
% Density of Plant Types
0 10 20 30 40 50 60 70 80 90
Season
Mature Spruce
W
Sp
S
Au
a.
Mature Pine
W
Sp
S
Au
b.
Deciduous
W
Sp
S
Au
c.

Fig. 3. cont'd (d to f).


Mean Pellet Groups Per Plot
0 1 2
A
0 1 2 3
B
0 1 2 3
C
0 10 20
% Density of Plant Types
0 10 20 30 40 50 60 70 80 90
Season
Plantation
W
Sp
S
Au
d.
Clearings
W
Sp
S
Au
e.
Rides
W
Sp
S
Au
f.

with score cover estimates in winter and autumn (see Table 10), and with canopy cover in all seasons except summer ($P < 0.05$; $P < 0.01$ in winter and autumn). Grasses and grasslike plants were the only important plant group. Its density was significantly ($P < 0.05$ in autumn; $P < 0.01$ in winter) correlated to deer use in winter and autumn only (Table 6).

Table 6. Rank correlation coefficients of counts of pellet groups with density of grasses and grasslike plants.

		Seasons			
Habitat Type	n	Winter	Spring	Summer	Autumn
Mature Pine	6	-0.26	0.55	-0.41	0.26
Deciduous	12	0.79[2.]	0.45	0.11	0.63[1.]
Plantation	18[a.]	0.22	-0.25	-0.11	0.10
Clearings	30	0.38[1.]	0.02	0.27	0.08
Rides	5[b.]	-0.05	-0.45	0	-0.40

[1.]Significant at $P = 0.05$ [2.]Significant at $P = 0.01$

[a.]16 in autumn

[b.]Cannot be compared with tabulated value at above significance levels as sample size is too small (Snedecor and Cochran 1967).

Table 7. Rank correlation coefficients of counts of pellet groups with density of *Picea sitchensis*

		Seasons			
Habitat Type	n	Winter	Spring	Summer	Autumn
Plantation	18	0.27	0.47[1.]	0.30	0.47[1.]
Clearings	30	-0.10	0.06	0.02	-0.19

[1.]Significant at $P = 0.05$.

The mature pine had lower numbers of pellet groups in spring and summer than in winter and autumn. There was an increase in the density of canopy and ground cover in the spring, which then remained constant during the summer but decreased in the autumn. Ground and canopy cover were not significantly ($P > 0.05$) related to faecal group numbers in any season (Tables 9 and 10), possibly a reflection of the small sample size. Grasses and grasslike plants were the most common plant type, but its density was not significantly related to numbers of pellet groups at any time (Table 6).

Table 8. Rank correlation coefficients of counts of pellet groups with the density of Calluna vulgaris

		Seasons			
Habitat Type	n	Winter	Spring	Summer	Autumn
Plantation	18	0.09	0.56[1]	0.47[1]	-0.19
Clearings	30	0.55[2]	0.22	0.27	0.15
Rides[a]	5	0.55	0.65	-0.52	0.72

[1] Significant at $P = 0.05$ [2] Significant at $P = 0.01$

[a] See Table 6.

In the plantation, fewer pellet groups were found in spring than in any other season. The density board and the score method both indicated an increase in cover during the spring which then remained constant during the summer. In autumn the score method indicated a decrease in ground cover whereas the density board suggested that it remained steady. The rank correlation coefficient of faecal group numbers with cover measured using the score method was significant ($P < 0.01$) in spring only (Table 10). No correlations were found between faecal group numbers and the density board estimates of ground cover (Table 9). Rank correlation coefficients could not be calculated for numbers of pellet groups with estimates of canopy cover, as the latter was absent. Ground vegetation was abundant in the plantation but with significant ($P < 0.05$) associations only for faecal counts with Picea in spring and autumn and with Calluna in spring and summer (Tables 7 & 8). Rank correlations between pellet groups and grasses and grasslike plants were variable between seasons, and indicated the absence of an association between these two factors (see Table 6).

Table 9. Rank correlation coefficients of counts of pellet groups with cover measured using the Wight Density Board.

		Seasons			
Habitat Type	n	Winter	Spring	Summer	Autumn
Mature Spruce	34	-0.36[1]	-0.09	-0.07	0.13
Mature Pine	6	0.20	0.71	0.03	0.93
Deciduous	12	0.58[1]	0.06	0.30	0.35
Plantation	18	0.09	0.14	0.03	-0.16
Clearings	30	-0.36	0.16	0.11	0.14
Rides[a]	5	-0.59	0.02	-0.55	-0.30

[1] Significant at P = 0.05

[a] See Table 6.

Table 10. Rank correlation coefficients of counts of pellet groups with cover measured using the score method.

		Seasons			
Habitat Type	Cover Type	Winter	Spring	Summer	Autumn
Mature Spruce	Canopy	0.42[1]	0.53[2]	0.45[1]	0.38[1]
Mature Pine	Canopy	0.74	0.65	0.65	-0.03
	Ground	0.57	0.79	-0.03	0.57
Deciduous	Canopy	0.79[2]	0.45	0.63[1]	0.72[2]
	Ground	0.79[2]	0.45	0.11	0.63[1]
Plantation	Ground	0.41	0.61[2]	0.22	0.32
Clearings	Ground	0.49[2]	0.12	0.47[2]	0.39[1]
Rides[a]	Ground	0.52	0.75	0.55	0.60

[1] Significant at P = 0.05 [2] Significant at P = 0.01.

[a] See Table 6.

The clearings habitat had mean numbers of pellet groups per plot which were similar in all seasons except spring when there was a reduction.

Ground cover increased slightly in spring and then decreased in autumn, according to both methods of estimating cover. Rank correlations for faecal groups with score cover estimates were significant ($P < 0.05$; $P < 0.01$ in winter and summer) in all seasons except spring (see Table 10), but with the density board estimates of cover the correlations were variable between seasons and not significant at any time (Table 9). Although ground vegetation was relatively common, faecal groups were significantly ($P < 0.05$) associated with grasses and grasslike plants and with Calluna in winter only (Tables 6 and 8). The low rank correlations between faecal groups and Picea indicated that these two variables were not associated at any time (Table 7).

The rides habitat had much higher numbers of pellet groups than any other habitat. Both methods of estimating ground cover indicated an increase in density in spring and a gradual decrease in summer and autumn. Rank correlations of faecal group numbers with estimates of cover and plant availability could not be tested for significance (see Tables 6,8,9 and 10).

3.3.4 Counts of Pellet Groups Related to Plant Availability in the Entire Study Area

Pellet group counts were significantly correlated ($P < 0.01$) during each season with the total density of ground vegetation, that is up to a height of 1.23 m., (Table 11), significantly correlated ($P < 0.01$) with the density of Picea sitchensis (Table 13) and Calluna (Table 14).

Table 11. Rank correlation coefficients of pellet group counts with the total density of vegetation.

Season	r_s	Significance Levels P = 0.05	P = 0.01	Sample Size
Winter	0.28	sig.	sig.	105
Spring	0.27	"	"	"
Summer	0.47	"	"	"
Autumn	0.49	"	"	103

Table 12. Rank correlation coefficients of pellet group counts with the density of grasses and grasslike plants over study area as a whole

Season	r_s	Significance Levels P = 0.05	P = 0.01	Sample Size
Winter	0.22	sig.	n.s.	105
Spring	0.11	n.s.	n.s.	"
Summer	0.33	sig.	sig.	"
Autumn	0.35	"	"	103

Table 13. Rank correlation coefficients of pellet group counts with the density of *Picea sitchensis* over study area as a whole.

Season	r_s	Significance Levels P = 0.05	P = 0.01	Sample Size
Winter	0.29	sig.	sig.	105
Spring	0.37	"	"	"
Summer	0.48	"	"	"
Autumn	0.49	"	"	103

Table 14. Rank correlation coefficients of pellet group counts with the density of *Calluna vulgaris* over study area as a whole.

Season	r_s	Significance Levels P = 0.05	P = 0.01	Sample Size
Winter	0.55	sig.	sig.	105
Spring	0.51	"	"	"
Summer	0.66	"	"	"
Autumn	0.59	"	"	103

3.3.5 Counts of Pellet Groups Related to Cover Density in the Entire Study Area

Numbers of pellet groups were significantly rank correlated ($P < 0.05$) with the density board estimates of ground cover only in winter (Table 15).

Table 15. Rank correlation coefficients of pellet group counts with density of cover over the study area as a whole, measured using the Wight Density Board.

Season	r_s	Significance Levels P = 0.05	P = 0.01	Sample Size
Winter	0.22	sig.	n.s.	105
Spring	0.10	n.s.	"	"
Summer	0.18	"	"	"
Autumn	0.19	"	"	103

Analyses relating the number of pellet groups to ground and canopy cover measured using the score method are shown in Table 16.

Table 16. Rank correlation coefficients of pellet group counts with the density of cover over the study area as a whole, measured using the score method.

Season	Ground Cover (r_s)	Canopy Cover (r_s)	Sample Size
Winter	0.31[2.]	-0.17	105
Spring	0.23[1.]	-0.25[1.]	"
Summer	0.40[2.]	-0.11	"
Autumn	0.48[2.]	-0.33[2.]	103

[1.] Significant at P = 0.05. [2.] Significant at P = 0.01.

There was a significant positive correlation ($P < 0.05$ in spring; $P < 0.01$ in winter, summer and autumn) between pellet group numbers and ground cover in each season. In contrast, pellet group numbers and canopy were inversely correlated throughout the year. The correlation coefficients were significant ($P < 0.05$ in spring; $P < 0.01$ in autumn) only in spring and autumn.

3.3.6 Territories

The territory size was estimated for eight bucks in 1973 and in 1974. Each buck could be identified by its antlers; none was marked with a collar. The sizes of the territories in each year, number of observations of individual bucks and the time interval between the first and last observation of an individual buck are given in Table 24. The distribution of the territories in 1973 and 1974 are illustrated in Figs. 4 and 5 respectively.

As is to be expected with a territorial animal, there was little overlap between neighbouring territories in either year; in some cases, a clear gap existed between them. For example, in 1973 at their closest points, the territory of buck number 8 was about 150 m. from that of number 13 (Fig. 4). In 1974 the corresponding territories occupied by bucks 26 and 33 (Fig. 5) overlapped slightly. More territories were separate in each year than had a common boundary.

The locations of territories in 1974 were in general similar to those in 1973. Territories of bucks 8, 13, 15, 17 and 12 in 1973 largely corresponded to those of 26, 33, 34, 23 and 40 respectively in 1974. Since territorial bucks are capable of holding their territories for several years, it was probable that in each case the same buck occupied the given territories in the two years. No territories were delineated in 1974 which corresponded to those of bucks 2 and 7 in 1973. Buck number 2 was shot in late August 1973. There was no indication in 1974 of a buck taking over its territory. Buck number 7 in 1973 could have been number 31 in 1974. The territory of this buck extended over parts of the territories held by numbers two and seven the previous year. No bucks were seen to take over the territories of bucks 31, 35 and 40 after each was shot. Buck number 8 was observed three times with doe 41 and four times with an unidentified adult doe. An adult doe was seen to accompany bucks 2, 7, 12, 26, 23, 33 and 34 on two, four, two, five, four, two and one occasion(s) respectively. Buck 31 was sighted in a winter group[1.] composed of an adult doe, yearling doe 46 and yearling buck 54, on nine occasions.

[1.] From Bramley (1970)

Table 17. Territories of bucks in 1973 and 1974.

Deer numbers in 1973	Age	Observations Number	Time Range	Territory Size (ha.)
2	Adult	13	11/4 - 10/8	11.5
4	"	10	24/4 - 27/7	12.8
7	"	14	30/3 - 31/8	14.5
8	"	17	12/4 - 26/7	13.7
12	"	10	24/4 - 31/8	5.5
13	"	8	2/6 - 24/6	11.2
15	"	7	11/4 - 8/8	11.5
17	"	8	26/4 - 14/8	7.0
				10.9 ± 1.1
in 1974				
23	"	13	28/3 - 30/7	10.6
26	"	15	21/3 - 3/7	15.3
31[a]	"	13	4/4 - 7/5	11.7
33	"	9	24/4 - 20/6	14.2
34[a]	"	8	30/4 - 1/7	10.0
35[a]	"	4	16/4 - 7/5	11.1
37	"	9	17/4 - 24/7	11.7
40[a]	"	5	16/4 - 24/7	7.3
				11.5 ± 0.9

[a] Shot during cull. Age determined from examination of teeth confirmed above age classification.

Each territory occupied parts of two or more habitat types. It was possible that topographic features such as stone walls formed parts of the territory boundary of bucks 8, 13, 15, 26, 33 and 34, and a stream may have also formed part of the territory boundary of bucks 13 and 33. All of these bucks had territories bordering on the fields habitat which was surrounded by a stone wall. Territory sizes in 1974 were not significantly ($P > 0.05$) different from those in 1973.

Fig. 4. Territories of bucks in 1973

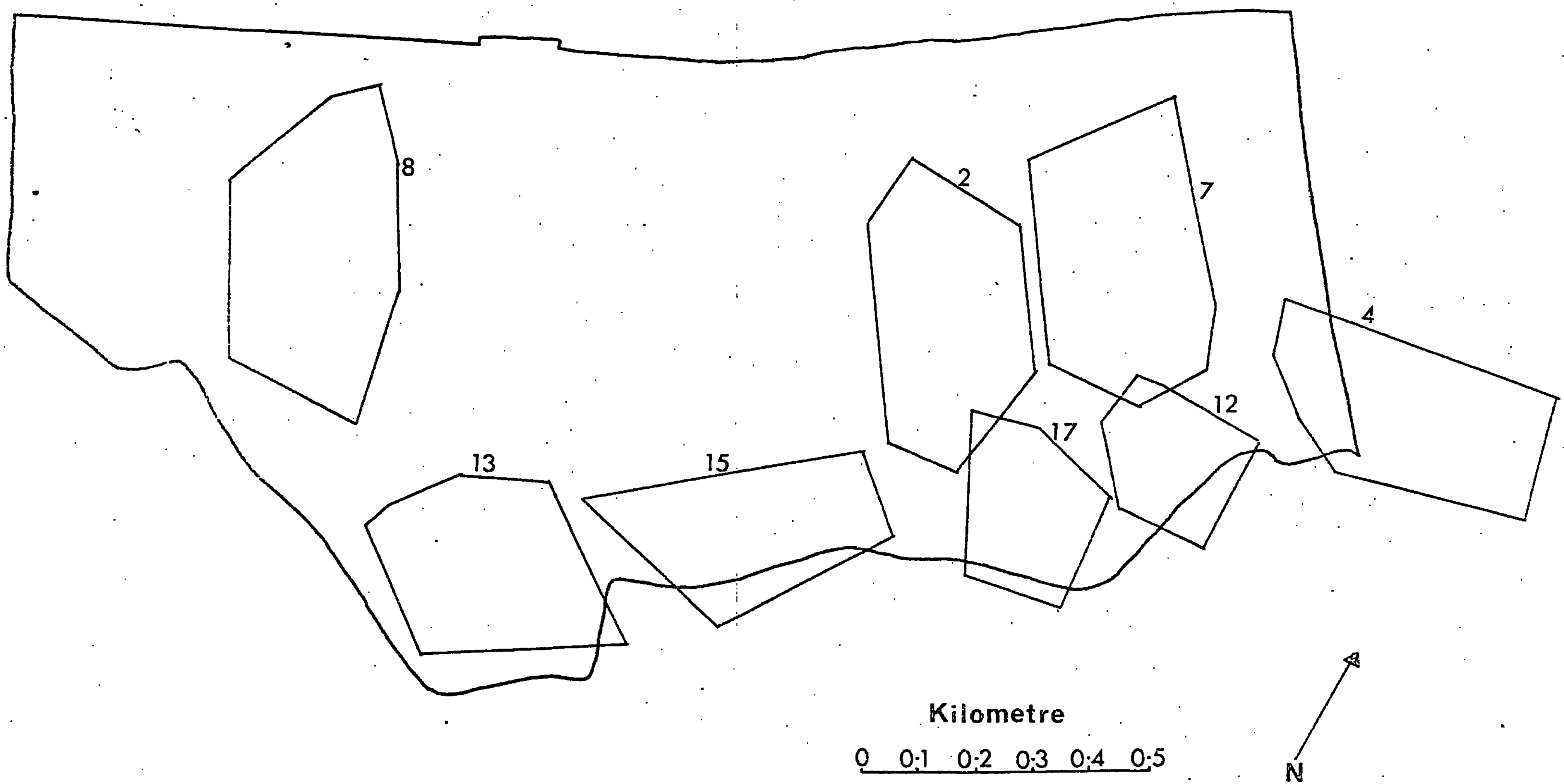
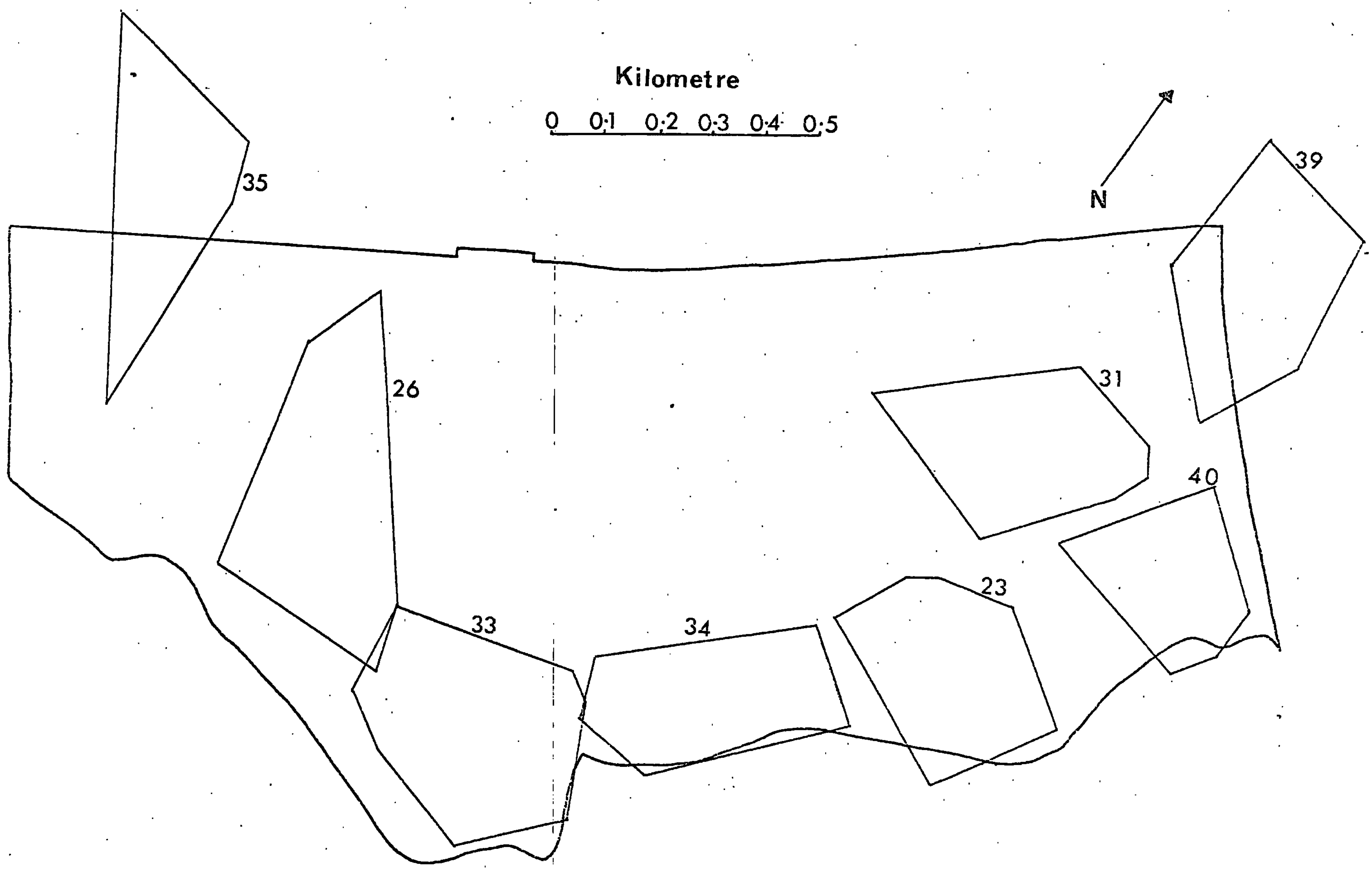

8
13
15
2
7
17
12
4
Kilometre
0 0·1 0·2 0·3 0·4 0·5
N

Fig. 5. Territories of bucks in 1974


Kilometre
0 0·1 0·2 0·3 0·4 0·5
N
35
26
33
34
23
31
40
39

3.3.7 Home Ranges of Non-Territorial Bucks

The home ranges of six and eight non-territorial bucks were estimated in 1973 and 1974 respectively. Details are given in Table 18 and Figs. 6 and 7. Only one of these bucks, number 10 in 1973, was classified as adult. Bucks 5 and 50 were each marked with a self-attaching collar. Bucks 55, 56 and 57 were ear-tagged as kids in 1973.

Bucks 5, 11 and 16 were always observed alone. Buck 11 was found dead outside of its home range as shown in Fig. 6, in September 1973. Buck 9 was often seen with an adult doe in the winter months, although during the time period shown in Table 18, it was solitary except for two occasions when an unidentified yearling doe accompanied it. Buck number 6, although usually solitary, was once observed with two unidentified yearling bucks. Number 10, also usually solitary, was seen twice with an unidentified adult doe. In 1974, bucks 50, 51, 53, 55 and 56 were always sighted alone. Number 52 and 57 were normally solitary but the former was observed twice with two unidentified yearling bucks and the latter twice with another yearling. The three ear-tagged yearlings were never seen together. There was a greater degree of overlapping of home ranges of bucks in 1974 than in 1973. The mean size of the home ranges was similar in each year and similar also to the mean territory size. Home ranges always occupied parts of two or more habitat types.

3.3.8 Home Ranges of Does

Home ranges were estimated for three does in 1973 and five in 1974. Details are given in Table 19 and Figs. 8 and 9. Does 41 and 44 (see Plate 7) were each marked with a self-attaching collar. Doe 45 was ear-tagged as a kid in 1973.

Of the does followed in 1973, number 41 was usually solitary, but was accompanied by buck number 8 on three occasions. Doe 42 had twin kids but one died. This doe was observed twice by itself and with the remaining

Table 18. Home ranges of non-territorial bucks in 1973 and 1974.

Deer Number in 1973	Age	Observations Number	Observations Time Range	Home Range (ha.)
6	Yearling	9	26/4 - 7/6	11.6
9[a]	"	7	16/4 - 3/5	10.1
10	Adult	8	4/5 - 7/8	13.9
16	Yearling	7	22/5 - 4/8	13.3
5	"	3	1/6 - 7/7	4.1
11[a]	"	5	26/4 - 7/5	13.4
				11.1 ± 1.5
in 1974				
50	Yearling	5	2/4 - 1/5	9.6
51[a]	"	5	7/4 - 6/5	8.1
52[a]	"	7	13/4 - 1/5	12.8
53	"	8	2/4 - 28/5	3.9
54	"	13	11/4 - 26/5	10.6
55[b]	"	17	13/4 - 12/6	20.1
56[b]	"	15	9/4 - 17/6	19.4
57[b]	"	9	10/4 - 25/7	7.6
				11.5 ± 2.0

[a] Shot during cull. Age determined from examination of teeth confirmed above age classification.

[b] Known age

Fig. 6. Home ranges of non-territorial bucks in 1973

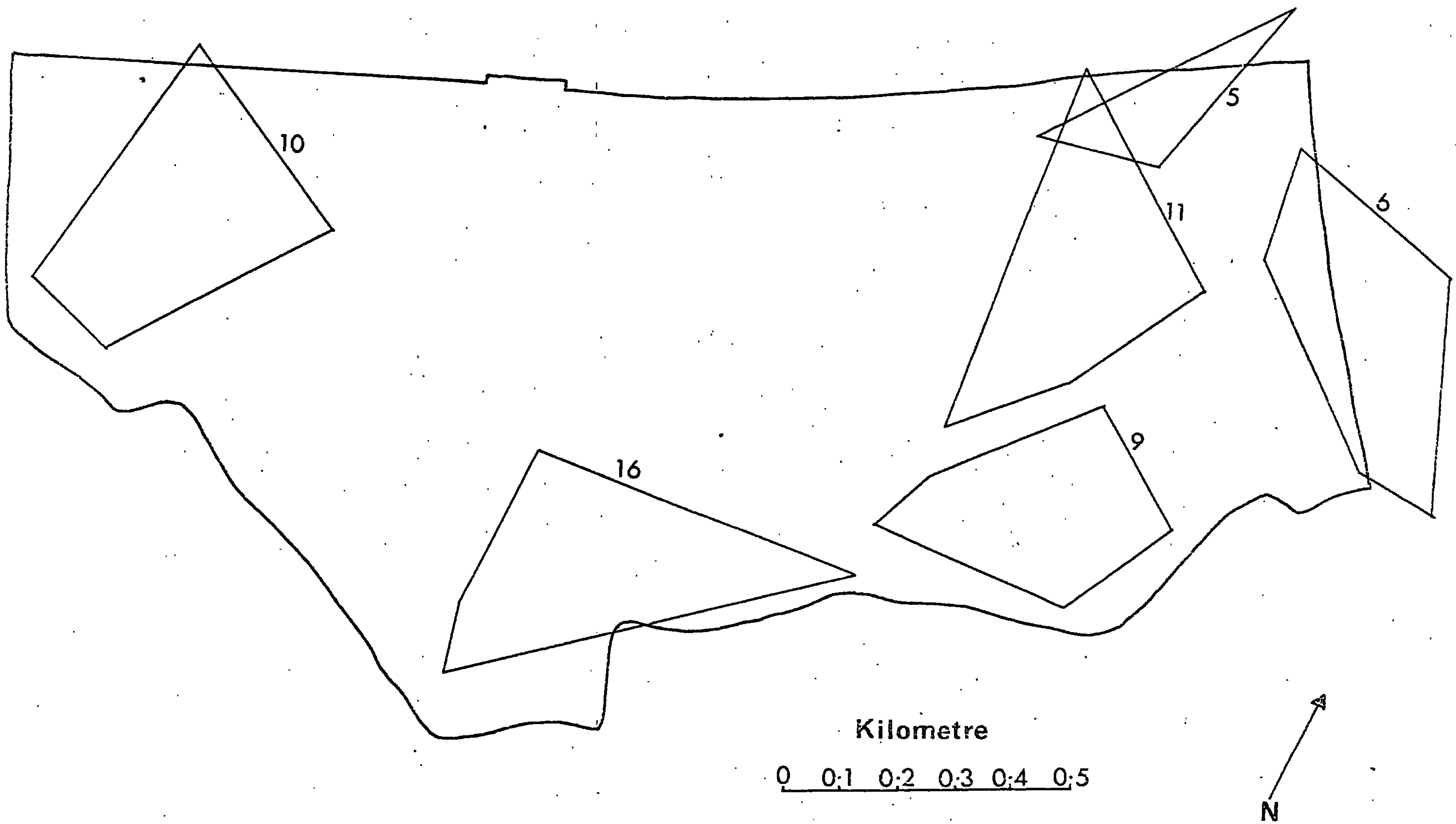

10
5
11
6
16
9
Kilometre
0 0·1 0·2 0·3 0·4 0·5
N

Fig. 7. Home ranges of non-territorial bucks in 1974.

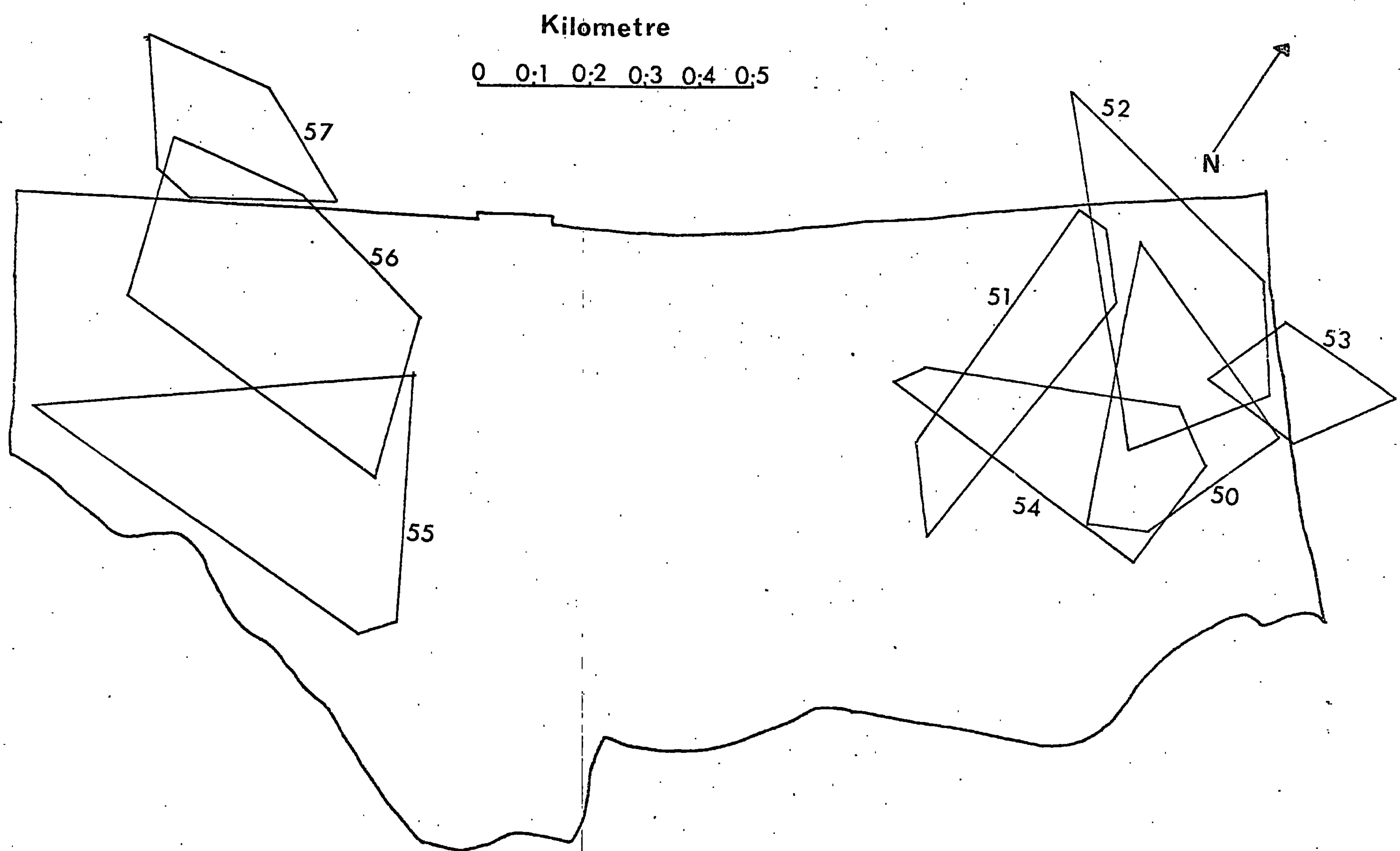

Kilometre
0 0·1 0·2 0·3 0·4 0·5
N
57
56
55
52
51
53
54
50

Plate 7. Doe No. 44. marked with a self-attaching collar (Clearings habitat type).

Table 19. Home ranges of does in 1973 and 1974

Deer Number in 1973	Age	Number	Observations Time Range	Home Range (ha.)
41	Yearling	10	27/5 - 31/7	6.5
42	"	10	16/6 - 2/8	7.1
43	Adult	9	2/6 - 1/8	10.5
				8.0 ± 1.2
in 1974				
44	Adult	13	8/5 - 25/7	32.3
45[a]	Yearling	8	24/4 - 25/7	13.9
46	"	12	10/4 - 5/6	14.7
47	"	9	20/5 - 5/7	9.7
48	Adult	14	17/4 - 29/6	11.9
				16.5 ± 4.0

[a] Known age.

kid on eight occasions. The kid was ear-tagged and in 1974 was yearling buck 56. Doe 43 had twins, one of which was ear-tagged and in 1974 was yearling buck 55. This doe was accompanied by its kids each time it was seen. Doe 44 had the largest home range of all bucks and does. This doe was observed three times in the winter of 1974 in an area approximately 1 km. west of the study area (see Fig. 9), but was not seen again until the following June. At this time, the doe was sighted close to the study area boundary but by early July was again in the area where it had been seen during the winter. Doe number 44 was always observed alone, as was doe 45 which was ear-tagged as a kid. Doe 46 was sighted alone three times but otherwise on the remaining occasions in the winter group of buck 31. Doe 47 was observed alone six times and on three occasions with another yearling doe. Doe 48 was seen once with each of territorial bucks 33 and

Fig. 8. Home ranges of does in 1973.

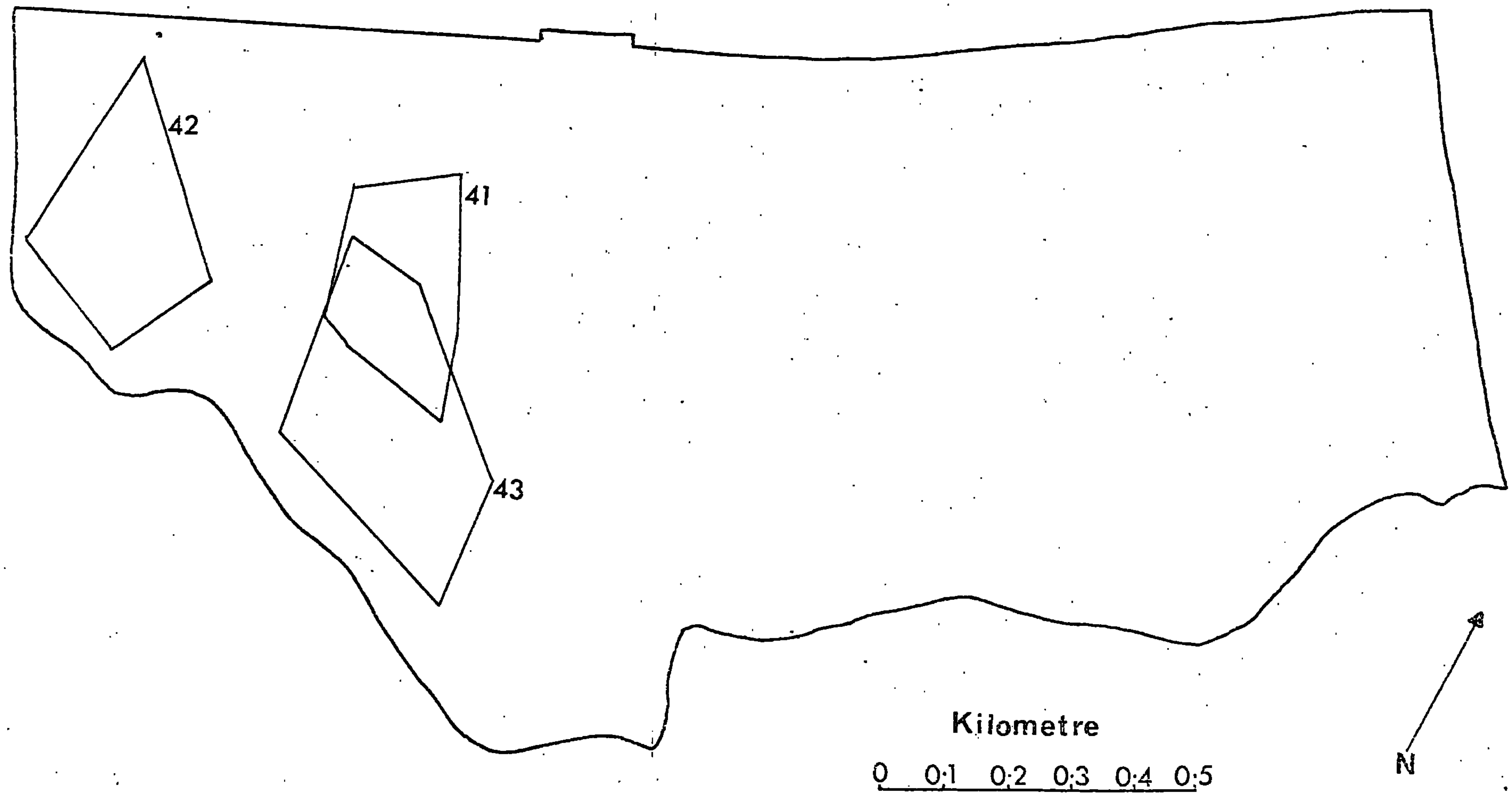
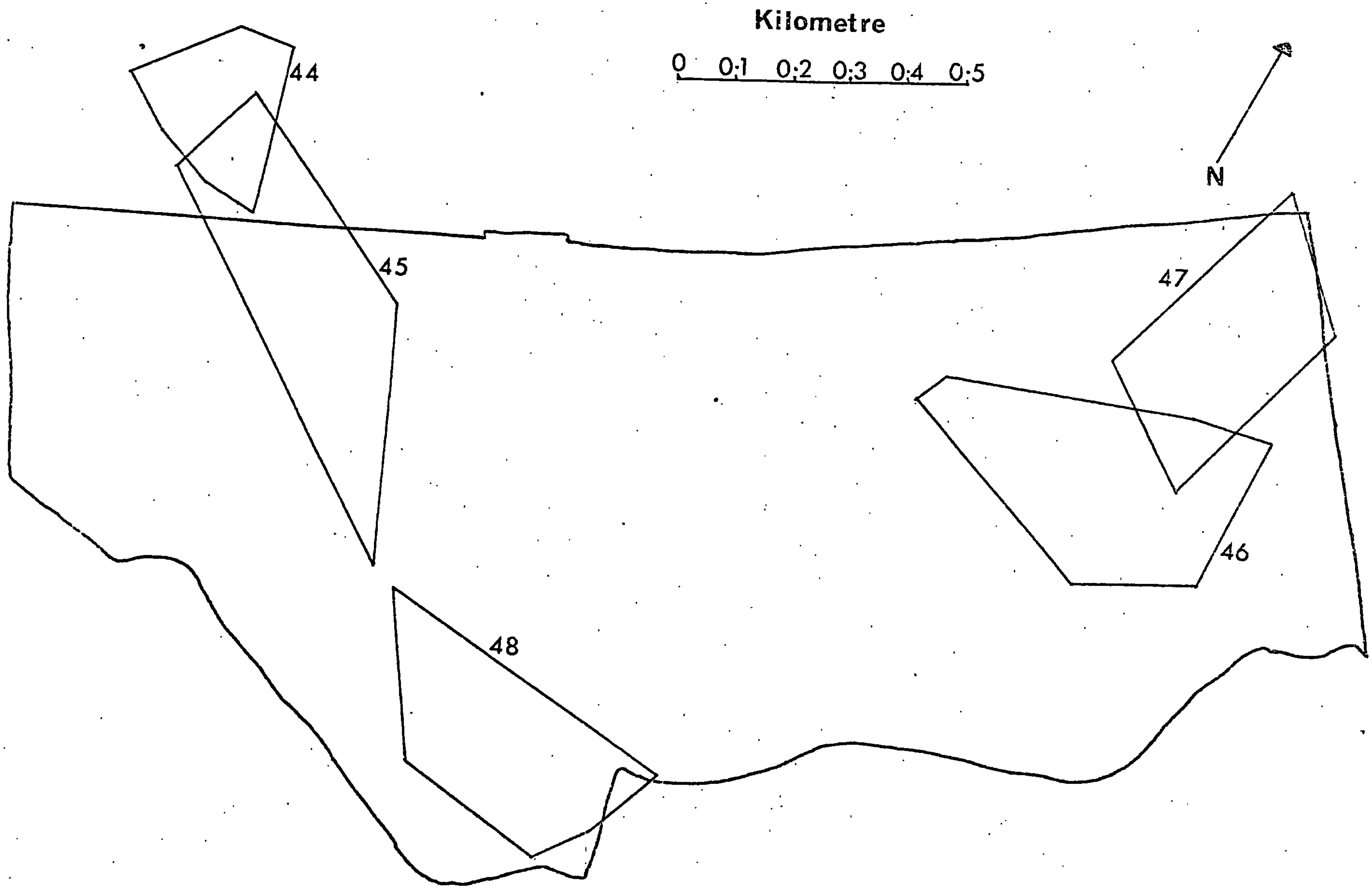

42
41
43
Kilometre
0 0·1 0·2 0·3 0·4 0·5
N

Fig. 9. Home ranges of does in 1974.
The home range of doe 44 is drawn
to the scale of 0.3 cm. = 100 m.



Kilometre
0 0·1 0·2 0·3 0·4 0·5
N
44
45
46
47
48

34 respectively and twice with a kid.

The mean home range size of does in 1974 was over twice the mean in 1973. Home ranges of does overlapped with those of non-territorial bucks and with the territories of territorial bucks. All doe home ranges occupied two or more habitat types.

3.4 Discussion

The random distribution of pellet groups within individual habitat types in all seasons, except for the plantation in winter, is attributed to the uniformity of the environment within each habitat. Random pellet group distributions of Cervus canadensis and Odocoileus hemionus within habitats were similarly explained by McConnell and Smith (1970). However, Bowden, Anderson and Medin (1969) found that pellet group distributions of O. hemionus within individual habitats were usually, though not always, clumped. Non-random distributions can be caused by aspects of social behaviour or by behavioural response to the physical habitat or both (Bowden et al 1969, McConnell and Smith 1970). The clumped distribution of the pellet groups in the plantation in winter was possibly the result of a behavioural response to sheep which congregate at this time in parts of the plantation. Since deer were never observed in the fields, which were grazed by sheep (Ovis aries), nor close to them in other parts of the forest, it is suggested that roe avoid sheep. Such avoidance could cause the deer to use only those parts of the plantation from which sheep are absent. Such behaviour could have the effect of producing greater numbers of pellet groups in some plots than others.

For most habitat types there was an absence of significant correlation (for exceptions see Section 3.3.3) between pellet group numbers and the density of each plant type, including Calluna the principal food (see Section 4). The fact that both pellet group numbers and estimates of the density of plant types extend over small ranges of values would tend to reduce the degree of correlation between them. Even so, the results are surprising given that according to Julander (1966), deer defecate mainly where they feed (see Section 3.1). More significant rank correlations than those shown in Section 3.3.3 might therefore be expected between faecal group numbers and the density of plant types in the rides and clearings habitats, particularly since these habitats were the main feeding areas, and the most preferred habitats according to both counts of pellet groups and observation data. It is possible that in roe, defecation may not be in fact associated with feeding, but rather with such other activities as moving or bedding. If this latter suggestion is true, then closer relationships might be expected between pellet group numbers and indices of cover in those habitats with attractive cover conditions for deer.

Quite close correlations were indeed indicated between pellet group numbers and ground cover as measured using the score method in the plantation, clearings and deciduous habitats and with canopy cover in the mature spruce and deciduous habitats. Cover as a factor influencing habitat selection by other cervids has been reported by Dzieciolowski (1969b) and Henry (1975). Canopy cover however, cannot be of absolute importance in habitat selection, as both counts of pellet groups and observation indicated the mature spruce and deciduous habitats to be the least preferred with the exception of the fields where the presence of sheep and cattle as well as the absence of cover may have reduced its use by deer.

The rank correlation coefficients of pellet group numbers with the density board estimates of ground cover were more variable than the correlations with the score method values of ground cover. This is surprising because the density board had a greater number of possible cover values which would be expected in principle to provide, with counts of pellet groups, closer correlations than would the small number of possible values provided by the score method. When using the density board, it might have been best to have taken more than the two readings made for a given plot and to have averaged these. Because the score method provided less variable rank correlation coefficients with numbers of pellet groups, it is suggested that it measures a parameter of cover which is of more importance to the deer than that measured by the density board.

Both counts of pellet groups and observation indicated differential use by deer of habitats within each season. Neither method is an absolute technique for determining the degree of habitat use as both suffer from the errors referred to in Section 3.2.1. However, estimates of habitat use based on counts of pellet groups, may be the more reliable because the method represents a continuous monitoring of use, whereas observation reflects use only in the evenings and mornings. It is probably best to employ the two methods in conjunction.

The clumped distribution of pellet groups over the study area as a whole in winter, spring and autumn was probably caused by marked differences in the environment of the different habitats. Clumped pellet group distributions were reported for deer in heterogeneous environments by Bowden et al (1969) and McConnell and Smith (1970). The random distribution of faecal groups over the study area in summer may have been caused by such environmental factors as the distribution of biting insects or areas of high temperature which superceded the influence of environmental heterogeneity, or possibly the random exploratory behaviour by kids led to their dams, likewise moving randomly as a result of following them.

The total number of pellet groups counted was lowest in spring. It was unlikely that at this time of year, many pellet groups were missed during the survey, or that many groups had been destroyed by insect attack, since vegetation was more dense and insects more abundant in summer when many more pellet groups were found. A possible cause of the low spring total was a reduction in deer numbers. Four dead deer were found in the study area in March and April 1973. Other animals may have died at that time, but were just not found. In addition, some bucks were shot on and around the study area during the cull in May. Subsequent movement of deer into the study area and the birth of kids might explain why the total number of pellet groups in summer returned to a level similar to that of winter.

For the study area as a whole, the closer relationship of pellet group numbers, as indices of deer distribution, to the density of *Calluna* than to that of any other plant type was not surprising as *Calluna* was the principal food. The closer association of pellet group numbers to the density of *Picea* than to that of grasses and grasslike plants, even though the latter was a more heavily used food than *Picea* (see Section 4), may be because *Picea* was frequently also used by bucks as a fraying stock and the trees were a source of cover. *Calluna* and grasses and grasslike plants also provide bedding areas for roe, and Jackson (1974) has noted that *Dama dama* regularly defecate after rising from bedding sites. In the present study, although a correlation was shown between food distribution and deer distribution, a more precise test for determining the importance of food in regulating roe distribution is necessary. This could be obtained by correlating indices of deer distribution with indices of the degree of use of the principal foods. Food distribution is known to influence the distribution of other cervids (Miller 1968, Anderson *et al* 1972a, b, Staines 1974) and of African ungulates (Mukinya 1973, Spinage 1974).

Deer distribution in the study area as a whole was significantly correlated with the density board estimates of ground cover only in winter but significantly correlated with the score method estimates of ground cover in all seasons. Ground cover might be expected to be more important in winter than in any other season because it is a source of shelter at a time when weather conditions are most severe. However, as reported by Squires (1975) for sheep, cover also provides privacy for the female during parturition, hides the young in the immediate post-natal period and is a means of escape from predators and aggressive conspecifics. Canopy cover, although not closely related to deer distribution over the study area as a whole, was important locally. The cover afforded by the canopy of mature even age timber stands, particularly conifer stands, is important to deer, especially in winter. In the winter yarding areas of Odocoileus virginianus, these stands reduce wind velocity and provide even temperature conditions (Verme 1965, Ozoga 1968).

Territorial boundaries often coincide with topographic features in roe deer (Bramley 1970, Hosey 1974, A. Louden pers. comm.), in Setonix brachyurus (Holsworth 1967) and in Vicunga vicunga (Franklin 1974). Where such features can be assumed to constitute the entire boundary of a territory, then its size can be estimated by measuring the area enclosed by these features (Hosey 1974). Using this 'boundary method', Hosey (1974) estimated the mean territory size of roe at Chedington in 1972 to be 9.8 ha., a greater value than the means of 5.7 ha., 8.1 ha. and 5.1 ha. for 1970 to 1972 respectively, which he estimated using the polygon method. These latter estimates were generally similar to the average territory sizes of 7.4 ha., for the same area given earlier by Bramley (1972). The mean territory sizes for the roe bucks at Hamsterley of 10.9 ha. and 11.5 ha. in 1973 and 1974 were larger than those at Chedington and there was less variation between years.

Considerable discussion has centred on the factors influencing territory and home range size. In the case of roe deer, Strandgaard (1972) suggested that home range size was related to food availability. Kitchen (1974) noted in Antilocapra americana that all territories of males which received a doe during the rut, had a water source and a place where the buck could corner the doe. Kitchen suggested that Antilocapra americana might select territories on the basis of forage abundance and quality, since individuals concentrated their use in certain parts of their territories. Smith (1968) has reported that in Tamiascium sp. (tree squirrels), territory size is inversely correlated with food supply. The defence of such a resource as food could accord with Brown's (1964) theory on territoriality that the energy and time expended in defending an area only has selective value if a resource in short supply could be effectively defended in that area. McNab (1963) suggested that a close relationship existed between home range size and the weight or metabolic rate of the animal. However, this view was dismissed by Holsworth (1967) when discussing the factors influencing home range and territory size in Setonix brachyurus.

Estes (1974) commenting on the territorial system of male gregarious African bovids also concluded that body size was unimportant and he stated that it was not obvious why one species defended a larger area than another, although the frequency and intensity of territorial interactions, tolerance of bachelors and herding of females appeared to be related to territory size. For example, with species holding small territories the herding and territorial encounters were frequent and intense, and aggression was directed against bachelors, while the opposite behaviour patterns were observed with species which held large territories (Estes 1974). Leuthold (1974) has stated that 'the expression of territoriality is affected to a large extent by the size, density and dispersion of an animal population, these in turn being governed by the quality of the habitat'. But as pointed out by Spinage (1974), the reasons for territoriality in one species may not be the same as those in another.

On the basis of the above discussion, differences in habitat structure might account for the differences in territory and home range size in roe deer between areas. The roe at Chedington having ideal habitat (Bramley 1972) might therefore have been expected, as was in fact observed, to have smaller territories than the deer in Hamsterley where the habitat is far from ideal. However, Strandgaard (1972) reported mean territory sizes of 30 ha. and 26 ha. for roe at Kalø, Denmark. Here almost all of the territories extended over farmland as well as forest. Since the farmland should help to provide a plentiful food supply, and with the forest providing available food and cover, a large territory might seem unnecessary under these conditions, yet the mean territory size is over twice that of Hamsterley.A.Louden (pers. comm.) has estimated mean territory size of roe deer in Glentress Forest, Peebles to be just over twice that at Hamsterley, yet from casual observation of Glentress, I would judge that the structure of the habitat there is similar to that at Hamsterley. Hosey (1974) investigating the influence of food abundance on roe territory size in Chedington, established that territories there contained the same amount of food, irrespective of size. This led Hosey to suggest that other factors, such as food quality and aggression, were important in influencing territory size.

At Hamsterley, the mean home range size of non-territorial bucks was the same in each year. At Chedington it varied between years: Bramley (1972) recorded a mean home range size of 15.0 ha. for the years 1966 and 1968, an estimate over twice those of 6.7 ha., 6.2 ha. and 3.9 ha. quoted in Hosey (1974) for the years 1970 to 1972. Hosey found that the non-aggressive yearlings, which were tolerated by the stand bucks, had larger home ranges than the more aggressive two and three year old non-territorial bucks which were restricted to smaller home ranges by territorial behaviour. A similar situation to this was not apparent at Hamsterley since, with one exception, all the non-territorial males followed in both years were yearlings. If the home ranges of more two and three year old bucks had been estimated at Hamsterley, then findings similar to those given by Hosey (1974) above for Chedington, might have been recorded.

At Chedington, the yearling bucks which were tolerated by the territorial males had a greater quantity of food available within their home ranges than the two and three year old bucks which were restricted to areas of inferior habitat (Hosey 1974). The non-territorial yearlings at Hamsterley all had home ranges which overlapped with territories and since these yearlings were tolerated by the stand bucks, it seems probable that the quantity of food available within the home ranges was similar to that in the territories. This could perhaps explain the finding at Hamsterley that in each year mean home range size of non-territorial males was the same as mean territory size.

At Hamsterley in 1973, the mean home range size of does was less than that of non-territorial bucks, a finding which accords with Hosey's (1974) work at Chedington. The high value for mean home range size of does at Hamsterley in 1974 of over twice that of the previous year, is possibly anomalous because the result was inflated by the exceptionally large (30 ha.) home range of doe 44, an estimate of home range size possibly more apparent than real because there may have been a shift in the location of a smaller home range. Therefore, the 30 ha. area incorporated more than one home range. Unlike the shift in home range reported in Bayless (1969) for Antilocapra americana, the doe at Hamsterley must have returned to its original area, if in fact it left it in the first instance.

The exploratory behaviour of kids may cause the home range size of the adult doe to increase following parturition and the early part of lactation (Miller 1970, Henry 1975). Such an effect of kids on the home ranges of does 43 and 48 was deduced, but not proven, since few observations were recorded on these does over the period concerned. Does presumably have abundant food within their home ranges, although Hosey (1974) was unable to find a correlation between home range size and mean food quantity within them. He attributed this to his inability to estimate home range boundaries accurately using the polygon method.

The restriction of the size of home range by high population densities in O. virginianus was implied by Marchinton and Jeter (1966) and reported by Marshall and Whittington (1968). However, for the same species, Bridges (1968) reported the opposite results while Henry (1972) found home range size to increase from summer to winter in the absence of any change in population density. As population density at Hamsterley was not known, its influence on territory and home range size cannot be discussed. At

Kalo, where population density is about 1 deer/4.0 ha. according to Strandgaard (1972), territory size is considerably greater than territory and home range size at Chedington, where the population density is about 1 deer/2.5 ha. (from Bramley 1972)[1]. However, these two areas have dissimilar habitats.

3.5 Summary

1. Observations were made of roe deer behaviour and habitat use during each month of 1973 and from April to July 1974 in an area of 213 ha. in Hamsterley Forest. In the same area, pellet groups were counted on 100 systematically and five randomly located 25 m. x 2 m. plots at the end of each season of 1973. On these plots estimates were made of the density of plant types using a percentage scale from DeVos and Mosby (1969), of ground and canopy cover using a qualitative score method and of ground cover using also the Wight density board (DeVos and Mosby 1969).

2. Pellet groups were distributed at random within individual habitat types, except for the plantation habitat in winter, while over the study area as a whole, they showed a clumped distribution. In discussion, it is suggested that the random distribution of pellet groups within individual habitats was due to the uniformity of the environment within each habitat, whereas the clumped distribution over the study area as a whole was due to marked differences in the environment of the different habitats.

3. Seasonal use of individual habitats was generally not significantly related to indices of plant type and cover density, while seasonal distribution over the study area as a whole was significantly related to these same indices, although canopy cover was not very important. Food and

[1] Home range sizes not given in Strandgaard (1972).

cover as factors influencing habitat choice and distribution are discussed.

4. The score method is considered a more valuable method of estimating ground cover than the Wight density board.

5. There was little change in the choice of preferred habitats between seasons: the rides and clearings being the most preferred. Counts of pellet groups within individual habitats are believed to indicate habitat preferences more reliably than observation, although it is probably best to use both methods together.

6. Territory sizes were similar to the home range sizes of non-territorial bucks. Mean home range size of does in 1974 was twice that of 1973. In discussion it is suggested that such factors as age, social status, parturition, population density, proximity of food and cover all act to influence home range and territory size.

4. DETERMINATION OF DIET

4.1 Introduction

In the determination of diet, it is often useful to employ several methods with the aim of comparing and evaluating not only the results, but also the techniques themselves. Standard Techniques of study are the analysis of stomach or rumen contents and of faeces. Both methods provide qualitative and quantitative data, the latter usually being expressed on a percentage basis. A third method is to estimate the proportion of the production of a plant species grazed or browsed by the herbivore concerned. One way of doing this is to compare plant growth inside and outside exclosures. The data obtained estimate the amount of food available and that used by the herbivore over a particular time period.

The reliability of the technique of rumen contents analysis was tested by Dirschl (1962). He screened the stomach contents of *Antilocapra americana* through sieves of various mesh sizes and compared the plant composition of the contents of each sieve. Dirschl found little difference in the mean species composition of the contents of the different sieves. In contrast, a similar test by Bergerud and Russell (1964) on the rumen contents of *Rangifer tarandus* led them to conclude that samples of larger plant fragments did not accurately indicate diet. However, if the fractions retained by all sieves were analysed, diet could be determined.

Stewart (1967) investigated the reliability of faecal analysis. He noted that plants which were readily digested had fewer epidermal fragments present in faeces than more indigestible plants. Hansen Peden and Rice (1973) suggested 'the degree of digestion influenced the mean weight loss per plant fragment to a greater extent than the effect of digestion in reducing the total number of plant fragments'. Furthermore, Hansen *et al* (1973) stated that even if the recognition of fragments of highly digestible plants decreased after digestion, the size of the change is often so small that the error would be of no biological importance, a view also taken by

Todd and Hansen (1973). An advantage of the technique of microscopic faecal analysis is that if the quantification method of Sparks and Malechek (1968) is used, percentage dry weight of the ingested plants can be estimated from the relative densities of recognisable plant fragments in herbivore faeces. This is a less laborious method for estimating the weight of plants used than the comparison of plant growth inside exclosures with that outside. This latter type of work has been carried out by Dzieciolowski (1969a) and Bobek, Weiner and Zielinski (1972) in Poland. Such work can provide data on preferred foods and the amount of energy utilised by the deer per hectare of forest in relation to the total energy produced (Bobek et al 1972).

The work described in this study will supplement the investigations of roe deer diet conducted by Hosey (1974) and in addition, provide new information on the seasonal diet. I have used each of the three methods described above in an effort to assess the reliability of these different techniques. Since stray sheep were present in the study area, the amount of dietary overlap of the two species was also determined.

4.2 Methods

4.2.1 Determination of Diet from Rumen Contents Analysis

Approximately one litre samples of rumen contents were collected during the period January 1973 to July 1974 from deer which were shot during routine Forestry Commission culling operations. Of these samples, 16 were from does killed in January and February (winter) 1973; 21 from bucks killed in May (spring) 1973; 24 from does killed in November (autumn) 1973; 21 from bucks in May and June (spring) 1974 and eight from bucks in July (summer) 1974. Each sample was collected in a polythene bag and frozen until just before examination. It was then thawed and successively washed in a 2.0 mm^2 and a 1.0 mm^2 mesh sieve in order to remove fine plant material. The contents of the sieves were spread out on an aluminium foil tray measuring 30 cm. x 20 cm. and examined using the point frame method of

Chamrod and Box (1964). A maximum of 100 point contacts were recorded per sample. The point frame method is efficient and relatively quick to carry out when all the items in the rumens can be easily identified, and when mean values of items in several rumens are required and not values for individual animals (Robel and Watt 1970). The method provides an estimate of the percentage volume and percentage frequency of occurrence of a plant species in a sample of rumens. The percentage volume of each plant species is derived from the number of points contacting that species in the sample as a percentage of the total. Percentage frequency of occurrence is the number of rumen samples (or deer) in which a given plant is found, expressed as a percentage of the total.

4.2.2 Estimation of Plant Availability

Plant availability was estimated to help establish if plants were used in proportion to their availability. Estimation of availability was based on a point sampling procedure. This involved a count of the number of species which contacted a bamboo cane held vertically at ground level.

At the end of June 1973, point sampling was conducted at 2.5 m. distances within pellet group plots. This gave 10 sample points per plot. It proved convenient to sample the vegetation at these distances because I was counting pellet groups on the plots at the same time. The method provided data on plant availability for 105 plots and thus at 1050 sampling points. Additional data were obtained from an arbitrary number of 170 sample points randomly located using the watch method in areas of edge.

In June 1974, plant availability was estimated using point sampling at five metre distances along random walks. The direction of each five metre distance was determined by the watch method. This random walking was also used by Allen (1968), and was chosen for convenience and because the faecal group plots of 1973 had been abandoned. It was assumed that data from a total of 500 sample points would provide a reliable index of plant availability. The distribution of these sample points between habitat types was: mature spruce 150, mature pine 50, deciduous 50, plantation 50, clearings 150 and rides 50.

Although this sampling was conducted at times when plant species are most plentiful, it was assumed that the data obtained could still be used as the basis of an index of plant availability during winter and autumn when certain plants and plant parts, eg. various annual herbs and the leaves of deciduous trees, are relatively less abundant. The above assumption was considered acceptable because only a simple index of availability expressed as percentage plant frequency was required, and not precise estimates of the dried weights of plant species in different seasons. For example, when point sampling in winter, the frequency of occurrence of the plant species should be the same as in summer, with the exceptions given above, even though the dried weight of the available vegetation in winter is much less than that in summer (Bobek et al. 1972), since only the number of individual species contacting the cane are recorded. It was also assumed that these plant availability data which were based on sampling conducted in the study area, were representative of the forest as a whole.

The data were classified according to the scale of relative availability devised by Chamrod and Box (1968).

Qualitative Description	Percent Frequency	Availability Factor
Rare	0 - 0.5	1
Occasional	0.51- 2.5	2
Frequent	2.51- 7.5	3
Abundant	> 7.5	4

Plant availability was compared with diet using the preference rating formula described by Chamrod and Box (1968).

$$\text{Preference Rating} = \frac{\text{\% Freq. of Occurrence} \times \text{\% Volume}}{\text{Availability Factor}}$$

Plant identification was based on Grant (1947), Hyde and Wade (1962) and Martin (1969).

4.2.3 Determination of Diet from Analysis of Faeces

During the last three weeks of each month between January 1973 and December 1974, ten pellets were collected from each fresh faecal group found in the study area. Each month's collection was stored in a separate jar containing 5% formaldehyde solution. It proved convenient to prepare seven pellets for analysis at a time. They were firstly softened in 5% sodium hydroxide solution in a beaker for 24 hours. The sodium hydroxide solution was then poured off and replaced by tap water, the resulting suspension boiled for 15 minutes with continous stirring, and the faecal material then allowed to settle. Boiling for this time proved adequate to prevent plant fragments adhering in clumps. The supernate was poured off and tap water added. The resulting faecal suspension was stirred, a small sample taken, placed on a slide, covered with a watch glass and examined at 100 times magnification. Plant species were identified by comparing the size, pattern and type of the cells in the fragments of cuticle and epidermis from the faecal sample with mounted preparations of the same from leaves and stems of known plants, and with a reference photomicrograph collection of the same prepared by Linley (1973). The procedure for preparation of mounts followed Zyznar and Urness (1969). Following McDougall (1972, 1975) counts were made of the number of recognisable plant fragments in 15 random areas of each slide.

The number of faecal pellets required to determine each month's diet was estimated as follows:

The plant group composition of one pellet from each monthly collection between January and May 1973 was determined by counting the number of identifiable plant fragments of each plant group and expressing this as a percentage of the total fragments of all plant groups. The following data are arcsine transformationsof these percentages (see Section 4.2.5).

Month	Plant Groups: Grasses and Grasslike Plants	Browse	Mosses and Ferns	Herbs
Jan.	39.5	44.1	9.5	16.5
Feb.	39.8	42.4	15.1	15.1
March	34.3	44.3	12.8	22.5
April	37.3	38.8	13.3	25.8
May	42.4	38.9	10.5	21.3

It was assumed that one pellet can be analysed by examining its contents on one slide. The number of pellets or slides required to estimate the mean of each plant group to within 10% of the mean with 90% confidence was calculated using the following formula from DeVos and Mosby (1969):

$$N = \frac{s^2 \times t^2}{(d \times \bar{x})^2}$$

t = 2.13 at 4 degrees of freedom (n - 1) at P = 0.1, d = designated accuracy of 20% times $\bar{x}$.

	Plant Groups: Grasses and Grasslike Plants	Browse	Mosses and Ferns	Herbs
$\bar{x}$	38.6	41.8	12.2	20.3
s^2	9.1	7.4	5.1	19.2
N	2.8	1.9	15.6	21.2

Overall N = 21; therefore the desired level of accuracy per month will be achieved by analyses of 21 pellets. Since I had collected a minimum number of 80 pellets per month, I decided to analyse 70 of these and to retain the remainder in case they might be useful for future analyses. In 1974, I analysed only 35 pellets per month because the technique proved more time consuming and laborious than originally anticipated and also because a comparison was to be made with the diet of stray sheep using all the habitat types in the study area except the fields. It was considered valid to compare the diets of the sheep and deer occupying the same habitats because wild and domestic ungulates have similar digestive abilities.

The faecal pellets of sheep were prepared for analysis as described for the deer. In order to determine seasonal diet, the year was split into periods having the same monthly composition as described for seasonal distribution and habitat use in Section 3.2.1.

4.2.4 Estimation of Summer Plant Abundance and Use in a small Conifer Wood

This work was carried out in a small wood, of area 53.4 ha., and known as Westmoor Plantation (see Fig. 1) which is situated at the northern corner of Hamsterley Forest. The classification of the habitat types in this wood was based on the same criteria as was used to describe those in the main study area (see Section 2). Six habitat types (see Fig. 10) were recognised as follows:

Birch Pine is dominated by 45 year old Pinus sylvestris but includes two tiny stands of 40 year old Betula sp.

Scots Pine is dominated by 20 year old pole stage Pinus sylvestris.

Larch is dominated by 20 year old pole stage Larix decidua.

Fir Spruce has 20 year old Pseudostuga menziesii predominant but Picea abies is important.

Plantation contains six year old Picea sitchensis and Pinus sylvestris.

Rides separate or form a boundary to all the pole stage compartments.

The number of exclosure plots required was calculated from data collected in a preliminary trial conducted at the end of March 1974. In this trial, ten 0.25 m^2 plots were randomly located in each habitat using the watch method. In each plot all vegetation, excluding trees, was cut at ground level. In the case of the latter, the current year's growth up to a height of 1.23 m. was clipped, but not the leader shoot if within this height range. Similarly, only the current year's growth from the clipped stems of Calluna and Vaccinium, was used. The plot size of 0.25 m^2 was chosen because it was believed that this was the maximum size of plot from which clipped vegetation could be handled in the restricted drying

Fig. 10. Habitat Types in Westmoor Plantation

Westmoor Habitat Types

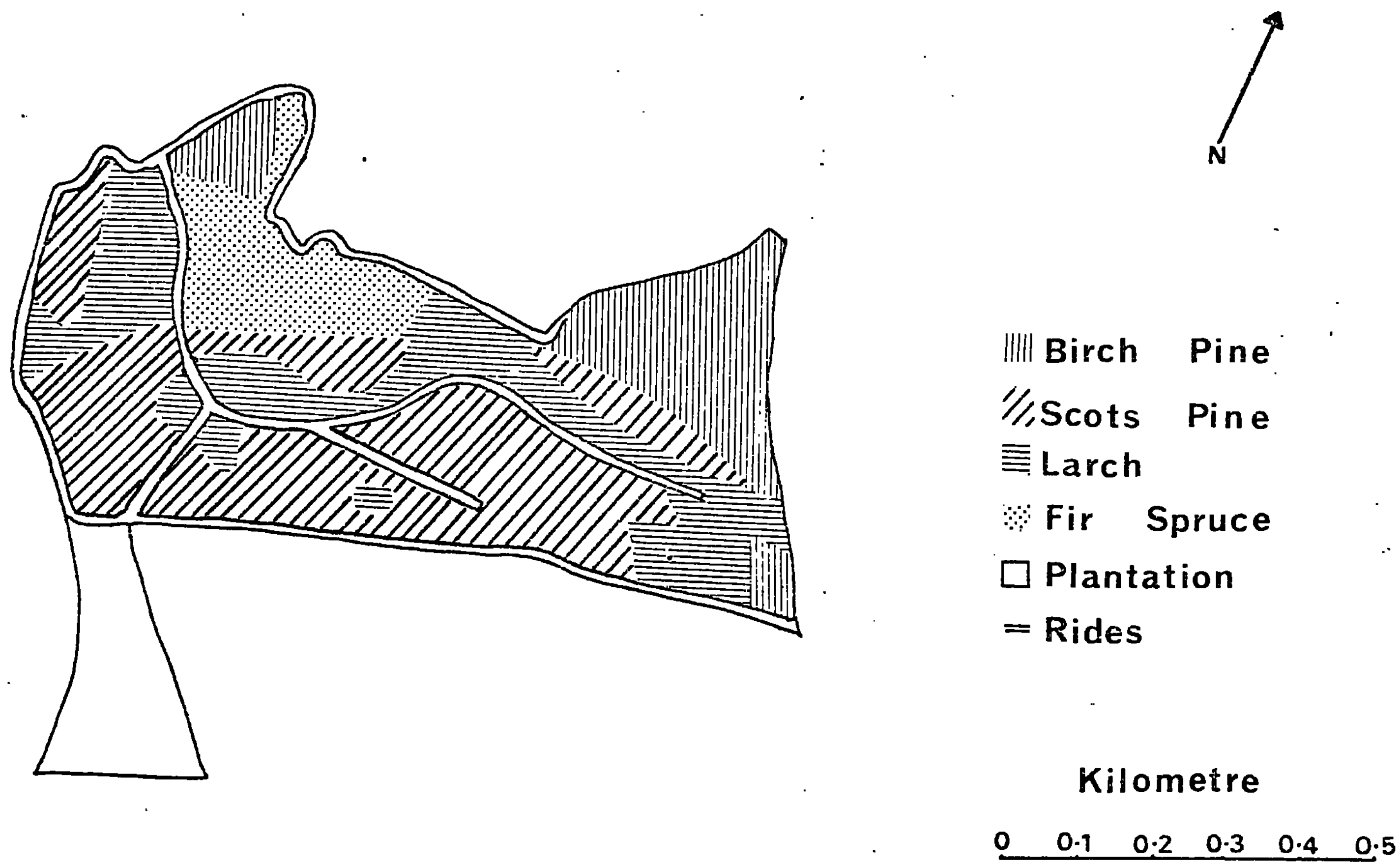
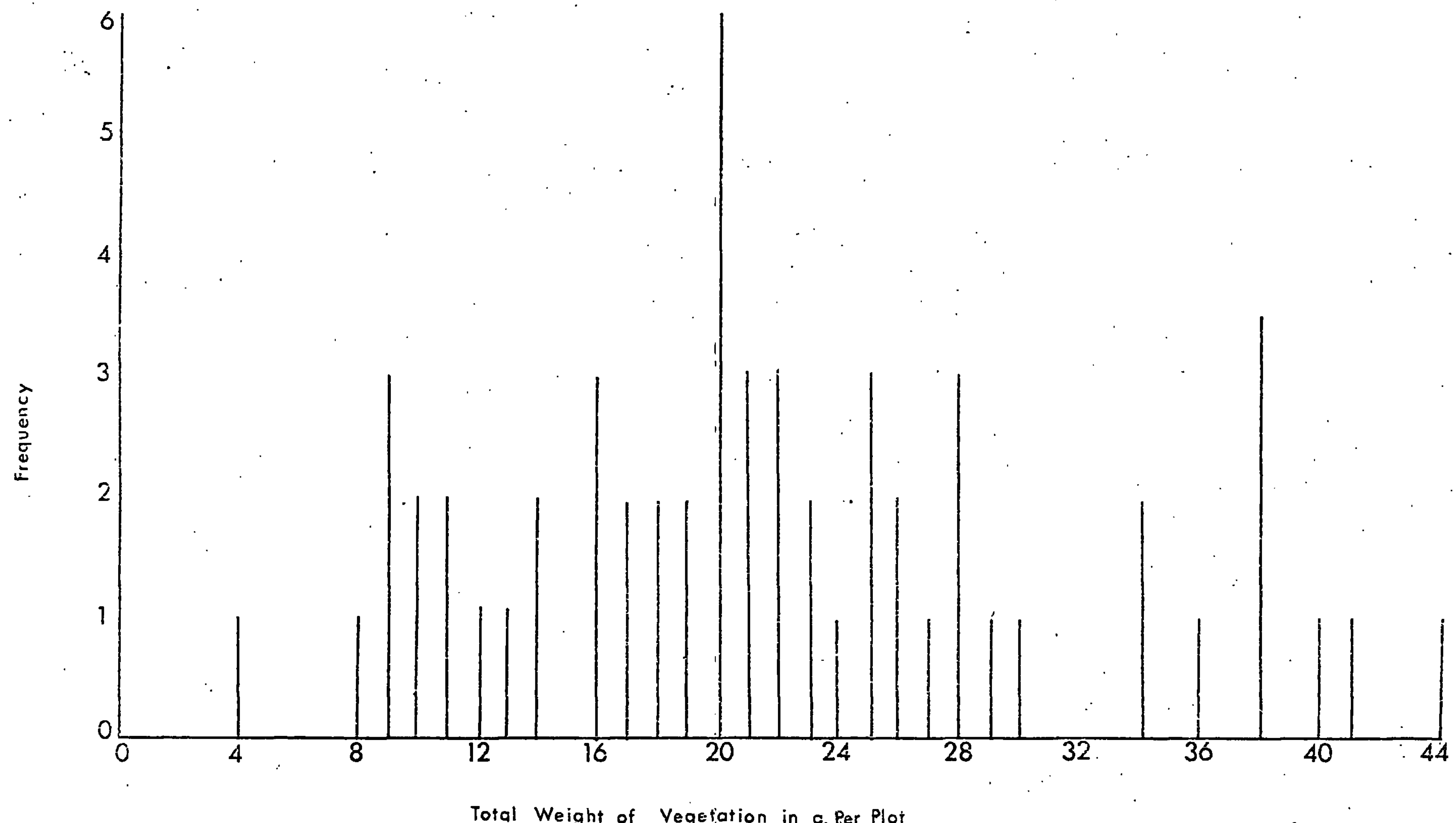


Fig. 11. Frequency distribution of the total weight of vegetation (to nearest gram) per $0.25m^2$ plot from six habitat types in Westmoor Plantation.


Frequency
0
1
2
3
4
5
6
0
4
8
12
16
20
24
28
32
36
40
44
Total Weight of Vegetation in g. Per Plot

facilities available in the laboratory. The material from each plot was air dried to constant weight.

The number of plots required per habitat (N) based on the data given below was calculated using the following formula from DeVos and Mosby (1969):

$$N = \frac{s^2 \times t^2}{(d \times \bar{x})^2}$$

where t = 2.26 for nine degrees of freedom at P = 0.05; d is the designated accuracy of 20% of the mean.

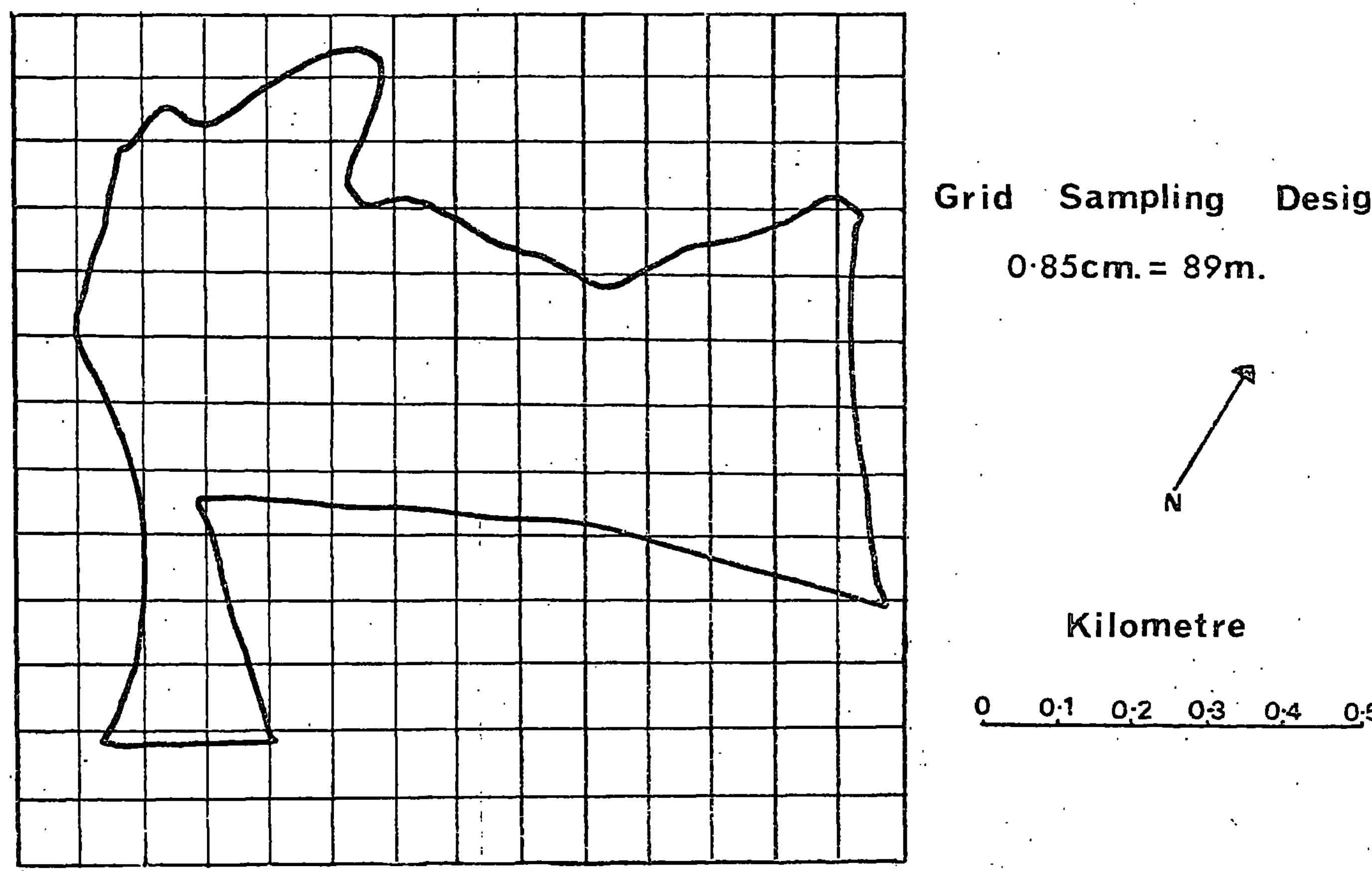
Habitat Type[1]	Mean ($\bar{x}$) dry weight of vegetation in grams	s^2	N
Birch Pine	19.7	70.0	23
Scots Pine	18.1	28.7	11
Larch	21.8	60.6	16
Fir Spruce	31.7	81.9	10
Plantation	26.7	44.1	8
Rides	15.2	52.7	29
		Total	97

[1] See Appendix 7.

This indicated that 97 plots would provide an estimate of the gross overall amount of vegetation available, accurate to within 20% of the mean. Since the amount of vegetation used was to be estimated by comparing the weight of vegetation clipped from a 0.25 m^2 plot inside each exclosure with that from the same size of plot outside, an overall total of 194 plots were required.

The preliminary data (see Appendix 7) when plotted as a frequency distribution (Fig. 11) form an approximately normal distribution only slightly skewed to the right. Ian Evans (pers. comm.) suggested that in view of this fact, it was permissable to treat the wood as a homogeneous habitat. Thus a grid sampling design (Fig. 12) could be used, except for the rides, the distribution of which did not permit the use of such a

Fig. 12. Grid sampling design used to sample plant type availability in Westmoor Plantation.



Grid Sampling Design

0·85cm. = 89m.

design. A 0.85 cm. grid overlay on a 1 cm. = 100 m. scale map proved the most suitable. Sampling was therefore conducted at 89 m. distances along an approximately northwest southeast bearing which was determined using a compass. Initially, the sides of each grid square were measured using a tape measure, but this proved laborious so pacing was substituted. Most of the plots which were positioned in the rides were located at random using the watch method.

A total of 82 plot markers were located during the 1st and 2nd of June 1974. At each of these positions, an exclosure measuring 1.5 m. x 1.0 m. x 1.0 m. and constructed of 2 cm. mesh nylon netting supported by four 2 m. bamboo canes, was erected. Netting with this size of mesh would be adequate to keep out rabbits (Oryctolagus cuniculus) and all large herbivores. It was assumed that any grazing by mammals smaller than rabbits and by invertebrates, would be the same inside and outside the exclosures and could be discounted in comparisons.

Between the 1st and 8th September, all vegetation within a 0.25 m^2 plot inside and outside each of 75 out of the 82 exclosures was clipped. The netting came off the remaining seven exclosures, so a total of only 150 plots was clipped.

The plants comprising the clipped samples were identified to the genus or species level, and then each was oven dried at 70°C for 48 hours to constant weight. This temperature was sufficient to drive off water, but not too hot to remove volatile substances (Telfer 1969).

4.2.5 Outline of Statistical Tests Used

In order to use anova to test for significant differences in the percentage occurrences of plant groups in samples of rumen contents and faeces, the percentages were transformed to angles by using the arcsine transformation. This transformation stretches out both tails of a percentage distribution, compresses the middle, and so makes the distribution normal. A single classification anova was used to analyse the data for each season based on examination of rumen contents, and a two way anova with replication was used to analyse the seasonal data from analysis of faeces. In this latter analysis, since there were three months per season and each month was considered as one replication, there were therefore three replicates per season. Plant groups, seasons and years were considered as fixed effects in the anovas. The means of the plant group data for rumen contents analysis and faecal analysis were analysed separately using the multiple comparisons SNK test to show between which means differences were significant. These SNK tests were all carried out at P = 0.05.

4.3 Results

4.3.1 Diet Determined from Rumen Contents Analysis

A total of 34 plant species, excluding the fungi and grasses, were identified from the 83 rumens examined. These species included nine trees, five dwarf shrubs, 13 herbs, three ferns, three grasslike plants and one moss. Grasses could not be identified to species level, because only pieces of leaf and or stem were present and never infloresences. Since more than one species of fungus occurred in the forest, I have assumed that the same was true of the rumen samples.

The frequency of occurrence of the plant species found in the study area are given in Appendix 6. The percentage frequency of occurrence, percentage volume, importance index, availability factor and preference rating of species used by the deer are given for each season in Tables 20 to 24. In the text the term trace refers to species with an occurrence value of 1% or less.

4.3.1.1 Food Preferences in the Winter of 1973

It is seen from Table 20 that <u>Calluna</u> was the most important and the most preferred food at this time, followed in order by grasses and grasslike plants, <u>Pinus</u>, <u>Picea</u> and <u>Vaccinium</u>. The remaining species were only of minor

Table 20. Occurrence and preference of food plants in the diet during the winter of 1973 (n = 16).

Species	% Frequency	% Volume	Index of[a] Importance	Availability Factor	Preference Rating
TREES					
Picea sitchensis	56.2	9.0	506	4	126
Pinus sylvestris	81.2	28.4	2306	4	576
DWARF SHRUBS					
Calluna vulgaris	93.7	41.2	3860	4	965
Erica tetralix	12.5	0.3	4	1	4
Rubus sp.	6.2	0.6	4	1	4
Vaccinium myrtilus	43.7	3.0	131	2	65
Unidentified browse	50.0	2.1	105	-	-
GRASSES AND GRASSLIKE PLANTS[b]	68.7	11.4	783	4	196
HERBS					
Galium saxatile	25.0	1.5	37	4	9
Pyrola sp.	6.2	1.6	10	1	10
Rumex sp.	12.5	0.1	1	1	1
Veronica scutellata	6.2	0	0	1	0
MOSSES					
Sphagnum sp.	6.2	0	0	2	0
FUNGI	6.2	0.5	3	1	3

[a] Importance equals % frequency x % volume.

[b] Grasslike plants include Carex sp., Eriophorum vaginatum, Juncus sp. and Luzula sp. Where grasslike plants could be identified to species level, they were excluded from the grouping of grasses and grasslike plants.

importance.

4.3.1.2 Food Preferences in the Spring of 1973 and 1974.

Twelve species only were identified in the rumen samples from the spring of 1973, whereas 29 were identified in those of spring 1974 (Tables 21 and 22).

Grasses and grasslike plants as a group, was the most preferred item in 1973, but ranked second to Chamaenerion in 1974. This latter species did not occur in any of the 1973 samples. Calluna and Vaccinium, the second and third most preferred plants in 1973 respectively, were the third and fourth most preferred in 1974. In 1973, Pinus sylvestris had a higher preference rating than Picea, whereas in 1974 the reverse was the case. Ranunculus was the fifth most preferred plant in 1974. The corresponding position in the previous year was held by Endymion which was absent from the 1974 samples. Luzula was the sixth most preferred species in both years.

4.3.1.3 Food Preferences in the Autumn of 1973

A greater number of species was present in the autumn samples of 1973 than in those of the winter and spring of that year (Table 23). Calluna was the most important and preferred food, followed, in order, by Rubus, fungi, Pinus sylvestris, grasses and grasslike plants and Vaccinium. The remaining species had preference ratings below 40.

4.3.1.4 Food Preferences in the Summer of 1974

Chamaenerion was the most preferred food followed in order by Calluna, Picea, Pseudostuga, grasses and grasslike plants, fungi and Vaccinium. The remaining species were minor constituents of the diet.

4.3.2 Seasonal Occurrence of Plant Groups in Rumen Samples

For the year as a whole, the plant group composition of the diet was 42.4% dwarf shrubs, 22.7% trees, 17.3% grasses and grasslike plants, 13.0%

Table 21. Occurrence and preference of food plants in the diet during the spring of 1973 (n = 14).

Species	% Frequency	% Volume	Index of Importance	Availability Factor	Preference Rating
TREES					
Picea sitchensis	14.3	6.0	86	4	21
Pinus sylvestris	21.4	10.8	231	4	58
DWARF SHRUBS					
Calluna vulgaris	64.3	29.7	1910	4	477
Vaccinium myrtilus	57.0	12.5	712	2	356
Unidentified browse	21.4	0.5	11	-	-
GRASSES AND GRASSLIKE PLANTS	92.8	27.8	2850	4	645
Luzula sp.	14.3	3.1	44	1	44
HERBS					
Endymion non-scriptus	14.3	3.5	50	1	50
Plantago sp.	7.1	2.3	16	2	8
Ranunculus sp.	21.4	1.2	26	2	13
Rumex sp.	7.1	0.1	1	1	1
Urtica dioica	14.3	1.9	28	2	14
FERNS					
Pteridium aquilinium	14.3	0.2	3	3	1

Table 22. Occurrence and preference of food plants in the diet during the spring of 1974 (n = 21).

Species	% Frequency	% Volume	Index of Importance	Availability Factor	Preference Rating
TREES					
Betula sp.	14.3	0.5	7	2	4
Ilex aquifolium	4.8	0	0	1	0
Larix decidua	19.1	0.5	9	2	5
Picea sitchensis	42.8	4.9	210	4	52
Pinus contorta	9.5	0.1	1	1	1
Pinus sylvestris	38.1	3.5	133	4	33
Pseudostuga menziesii	4.8	1.0	5	1	5
Quercus sp.	4.8	0.3	1	2	1
DWARF SHRUBS					
Calluna vulgaris	71.4	21.2	1514	4	378
Erica tetralix	4.8	0	0	1	0
Rubus sp.	14.3	0.6	8	1	8
Ulex europaeus	4.8	0	0	1	0
Vaccinium myrtilus	52.4	11.1	582	3	194
Unidentified browse	19.0	3.0	57	-	-
GRASSES AND GRASSLIKE PLANTS	100	21.9	2190	4	547
Luzula sp.	23.8	4.5	107	2	53
Eriophorum vaginatum	9.5	0.3	3	2	1
Juncus sp.	4.8	0	0	4	0
HERBS					
Crepis sp.	4.8	0.5	2	2	1
Chamaenerion angustifolium	47.6	11.9	566	1	566
Galium saxatile	19.0	0.8	15	4	4
Lotus sp.	19.0	1.8	34	2	17
Oxalis acetosella	14.3	0.2	3	2	1
Plantago sp.	19.0	2.1	40	2	20
Potentilla erecta	4.8	1.4	7	2	3
Ranunculus sp.	19.0	3.8	72	1	72

/continued

Table 22 cont'd.

Species	% Frequency	% Volume	Index of Importance	Availability Factor	Preference Rating
HERBS cont'd.					
Rumex sp.	23.8	0.6	14	2	7
Urtica dioica	4.8	0	0	2	0
Veronica scutellata	4.8	0	0	2	0
FERNS					
Pteridium aquilinium	14.3	2.3	33	4	8
Unidentified vascular plants	14.3	0.3	4	-	-

Table 23. Occurrence and preference of food plants in the diet during the autumn of 1973 (n = 24).

Species	% Frequency	% Volume	Index of Importance	Availability Factor	Preference Rating
TREES					
Betula sp.	20.8	0.5	10	2	5
Fagus sylvatica	16.7	0.2	3	1	3
Picea sitchensis	41.6	1.4	58	4	14
Pinus sylvestris	75.0	7.7	577	4	144
Pseudostuga menziesii	4.2	0.1	0	1	0
Quercus sp.	12.5	1.3	16	2	8
Unidentified leaves	29.2	9.3	271	-	-
DWARF SHRUBS					
Calluna vulgaris	87.5	41.6	3640	4	910
Erica tetralix	12.5	0.5	6	1	6
Rubus sp.	45.8	14.0	641	1	641
Vaccinium myrtilus	66.7	3.4	227	2	113
Unidentified browse	4.2	0.3	1	-	-
GRASSES AND GRASSLIKE PLANTS	83.3	6.1	508	4	127
Luzula sp.	8.3	3.1	26	1	26
HERBS					
Galium saxatile	16.7	0.5	8	4	2
Ranunculus sp.	4.2	0	0	2	0
Rumex sp.	29.2	0.5	15	1	15
FERNS					
Blechnum spicant	25.0	1.2	30	1	30
Dryopteris sp.	37.5	1.8	67	2	33
Pteridium aquilinium	20.8	2.6	54	3	18
FUNGI	70.8	2.9	205	1	205

Table 24. Occurrence and preference of food plants in the diet during the summer of 1974 (n = 8).

Species	% Frequency	% Volume	Index of Importance	Availability Factor	Preference Rating
TREES					
<u>Picea sitchensis</u>	62.5	18.2	1137	4	284
<u>Pinus sylvestris</u>	12.2	0.2	2	4	0
<u>Pseudostuga menziesii</u>	25.0	6.7	167	1	167
DWARF SHRUBS					
<u>Calluna vulgaris</u>	50.0	27.5	1375	4	344
<u>Vaccinium myrtilus</u>	62.5	1.6	100	3	33
Unidentified browse	12.5	0.4	5	-	-
GRASSES AND GRASSLIKE PLANTS	75.0	8.1	607	4	152
<u>Luzula</u> sp.	12.5	0.1	1	2	0
HERBS					
<u>Chamaenerion angustifolium</u>	50.0	23.7	1185	1	1185
<u>Galium saxatile</u>	37.5	1.1	41	4	10
<u>Lotus</u> sp.	12.5	0.1	1	2	0
<u>Oxalis acetosella</u>	12.5	2.0	25	2	12
<u>Potentilla erecta</u>	12.5	0.2	2	2	1
<u>Ranunculus</u> sp.	25.0	0.2	5	1	5
<u>Rumex</u> sp.	12.5	0.9	11	2	5
<u>Trifolium</u> sp.	12.5	0.7	9	2	4
FERNS					
<u>Dryopteris</u> sp.	12.5	0.1	1	2	0
FUNGI	25.0	3.5	87	1	87
Unidentified vascular plants	25.0	4.2	105	-	-

Fig. 13. Occurrence of plant groups in rumen contents in different seasons.

D = Dwarf Shrubs

T = Trees

G = Grasses and Grasslike Plants

H = Herbs

O = Other Plant Groups (Mosses, Ferns, Fungi)

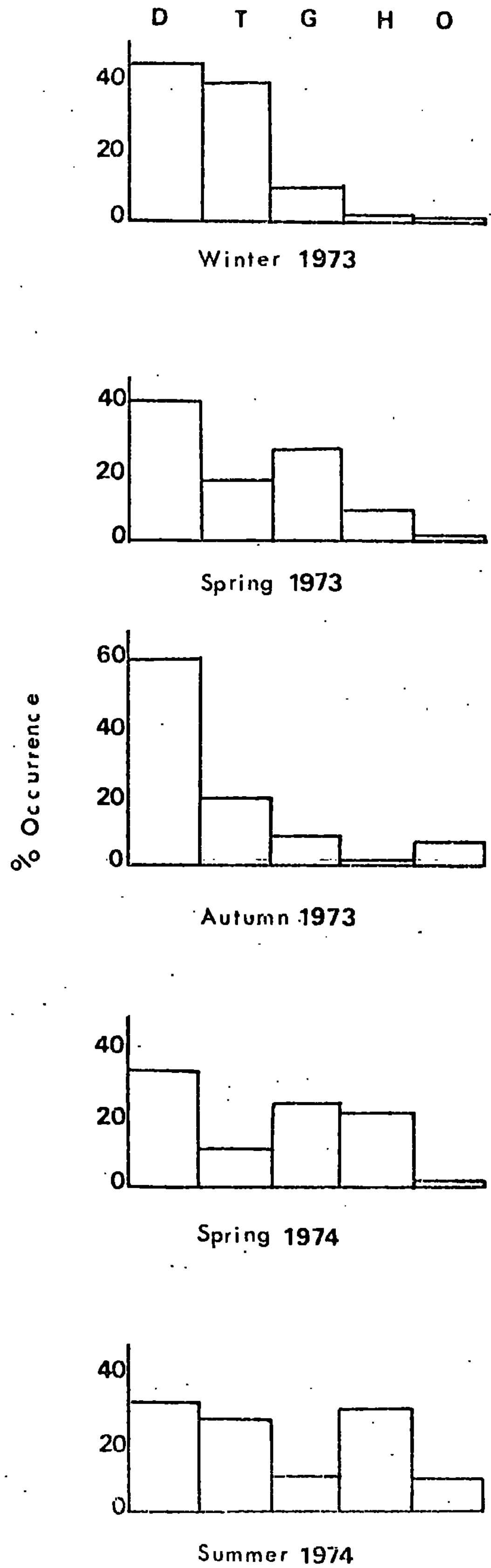

D
T
G
H
O
40
20
0
Winter 1973
40
20
0
Spring 1973
% Occurrence
60
40
20
0
Autumn 1973
40
20
0
Spring 1974
40
20
0
Summer 1974

Table 25. Single classification anova of different plant groups occurring in the rumen samples within seasons.

Source of Variation	d.f.	S.S.	M.S.	F_s
Winter 1973				
Among plant groups	4	22554.39	5638.59	39.07[1.]
Within plant groups	75	10822.74	144.30	
Total	79			
Spring 1973				
Among plant groups	4	17230.15	4307.53	12.37[1.]
Within plant groups	65	22625.61	384.08	
Total	69			
Autumn 1973				
Among plant groups	4	36532.44	9133.11	60.81[1.]
Within plant groups	115	17270.33	150.17	
Total	119			
Spring 1974				
Among plant groups	4	11447.64	2861.91	10.98[1.]
Within plant groups	100	26056.46	260.56	
Total	104			
Summer 1974				
Among plant groups	4	3589.75	897.43	2.13[n.s.]
Within plant groups	35	14711.68	420.33	
Total	39			

[1.] Significant at P = 0.01

[n.s.] not significant at P = 0.05

Table 26. Multiple comparisons of mean occurrences of plant groups in rumen samples within seasons.

Winter 1973

	Other Plants	Herbs	Grasses and Grasslike plants	Trees	Dwarf Shrubs
Rank:	1	2	3	4	5
Mean:	1.38	5.26	14.51	37.53	42.56

Spring 1973

	Other Plants	Herbs	Trees	Grasses and Grasslike Plants	Dwarf Shrubs
Rank:	1	2	3	4	5
Mean:	0.99	9.45	17.78	31.96	38.41

Autumn 1973

	Herbs	Other Plants	Grasses and Grasslike Plants	Trees	Dwarf Shrubs
Rank:	1	2	3	4	5
Mean:	3.98	14.40	14.47	23.82	52.56

Spring 1974

	Other Plants	Trees	Herbs	Grasses and Grasslike Plants	Dwarf Shrubs
Rank:	1	2	3	4	5
Mean:	2.95	17.51	24.76	29.17	32.26

Differences not significant at P = 0.05 are underlined

herbs and 3.9% other plant groups (consisting of fungi, mosses and ferns). None of the other plant groups was important individually over the year as a whole. I have assumed that unidentifiable browse was derived equally from trees and shrubs. The relative proportions of each of these plant groups in the seasonal diet are illustrated in Fig. 13.

The occurrence of browse decreased in spring and summer relative to winter, while that of herbs, grasses and grasslike plants increased. This change was reversed in the autumn. The other plant groups were more heavily used in summer and autumn than at any other time. Analysis of these data using a single classification anova indicated that the occurrences of plant groups in the diet differed significantly ($P < 0.01$) within all seasons except summer (Table 25).

For those seasons within which the mean occurrences of plant groups were significantly different from each other, the SNK test was used to test between which individual groups differences were significant (Table 26). It is seen that in winter the proportion of dwarf shrubs was not significantly different ($P > 0.05$) from that of tree browse, but both of these plant groups had significantly higher occurrences than the remaining groups. In spring 1973, the occurrence of dwarf shrubs did not differ significantly from that of grasses and grasslike plants, but both of these plant groups had significantly higher ($P < 0.05$) proportions than all of the remaining groups. In spring 1974, the volume of dwarf shrubs was significantly different only from that of tree browse and other plant groups. In the autumn, dwarf shrubs and tree browse were significantly different ($P < 0.05$) from each other and from all of the remaining groups.

A single classification anova was also used to test for significant differences in the occurrence of individual plant groups in the diet among seasons (Table 27). It was found that the occurrence of individual plant groups was significantly ($P < 0.01$) influenced by season.

The SNK test was then used to find out between which reasons means

Table 27. Single classification anova of individual plant groups occurring in rumen samples among seasons.

Source of Variation	d.f.	S.S.	M.S.	F_s.
		Dwarf Shrubs		
Among Seasons	4	6519.02	1629.75	4.68[1]
Within Seasons	78	27140.51	347.95	
Total	82			
		Trees		
Among Seasons	4	4425.005	1106.251	3.62[1]
Within Seasons	78	23835.439	305.582	
Total	82			
		Grasses and Grasslike Plants		
Among Seasons	4	5219.86	1304.96	6.33[1]
Within Seasons	78	16070.31	206.02	
Total	82			
		Herbs		
Among Seasons	4	9015.87	2253.96	8.91[1]
Within Seasons	78	19734.28	253.00	
Total	82			
		Other Plants		
Among Seasons	4	2581.49	645.37	8.79[1]
Within Seasons	78	5355.87	73.36	
Total	82			

[1] Significant P = 0.01

Table 28. Multiple comparisons of mean occurrences of individual plant groups in rumen samples among seasons.

Dwarf Shrubs

	Summer 1974	Spring 1974	Spring 1973	Winter 1973	Autumn 1973
Rank:	1	2	3	4	5
Mean:	26.93	32.26	38.41	42.56	52.56

Trees

	Spring 1974	Spring 1973	Summer 1974	Autumn 1973	Winter 1973
Rank:	1	2	3	4	5
Mean:	17.51	17.78	20.69	23.82	37.53

Grasses and Grasslike Plants

	Summer 1974	Autumn 1973	Winter 1973	Spring 1974	Spring 1973
Rank:	1	2	3	4	5
Mean:	12.59	14.47	14.51	29.17	31.96

Herbs

	Autumn 1973	Winter 1973	Spring 1973	Spring 1974	Summer 1974
Rank:	1	2	3	4	5
Mean:	3.98	5.26	9.45	24.76	32.46

Other Plants

	Spring 1973	Winter 1973	Spring 1974	Summer 1974	Autumn 1974
Rank:	1	2	3	4	5
Mean:	0.99	1.38	2.95	5.71	14.40

Differences not significant at P = 0.05 are underlined

were significantly different (see Table 28). The proportions of dwarf shrubs were significantly different ($P < 0.05$) only between the autumn of 1973 and the spring and summer of 1974. Differences in the volumes of tree browse among seasons were mostly not significant ($P > 0.05$). The occurrences of grasses and grasslike plants did not differ significantly between each spring, but the volumes for both springs were significantly higher than in the remaining seasons. The proportions of herbs in spring and summer 1974 were not significantly different from each other, but they did differ significantly ($P < 0.05$) from occurrences at all other times. The occurrence in the autumn diet of the other plant group was significantly higher ($P < 0.05$) than the value in each other season.

4.3.3 Diet of Deer Determined from Analysis of Faeces

A total of 43 and 45 plant species was identified from faeces in 1973 and 1974 respectively (see Tables 29 and 30). In 1973, these consisted of seven trees, three dwarf shrubs, 12 herbs, 13 grasses and grasslike plants, six mosses and three ferns. One additional tree and one herb were identified in 1974. The percentage occurrences of plant species in the faeces for each month of 1973 and 1974 are shown in Tables 29 and 30, and the annual indices of importance and preference for the same years, in Tables 31 and 32. The following text deals firstly with those species that have the highest preference ratings.

4.3.3.1 Monthly Occurrences of Plant Species in the Faeces and Annual Plant Preference Ratings

The main constituents identified in the faeces were as follows (Table 29):

Calluna vulgaris was the most heavily used and most preferred food in both years. Use in each year decreased from February until June, then increased to reach a peak for the year in October in 1973 and September in 1974, which was followed by a decrease.

Luzula sp. was the most frequently occurring grasslike plant in the faeces and the second most preferred food in the diet in each year. Use increased from February to May, decreased from June until October and then again increased through until the following spring.

Blechnum spicant was the third most preferred species in the diet. Peak occurrence in 1973 was in September and in August in 1974.

Pinus sylvestris was the most heavily used tree browse and the fourth and fifth most preferred species in the diet in 1973 and 1974 respectively. In each year, use decreased from January to May, increased slightly in June and then continued to decrease until November in 1973 and October in 1974.

Holcus sp. was the most heavily used grass and immediately followed _Pinus sylvestris_ in preference value in each year. In 1973, occurrence in the faeces was greatest from March to May and in 1974 from April to June. There was a second peak usage in October in 1974.

Pinus contorta was the sixth and tenth most preferred species in the 1973 and 1974 annual diets respectively. Even so, its mean occurrence in the faeces in 1973 was only just above the trace level and in 1974 was below it.

Dryopteris sp. was the seventh and fourth most preferred species in 1973 and 1974 respectively. The mean occurrence in the faeces was similar in each year. Maximum occurrence was in September in 1973 and in August in 1974.

Picea sitchensis was the second most frequently occurring tree browse in the faeces, the eighth most preferred species in the diet in 1973 and the seventh in 1974. In each year, use decreased from February to May. In 1973, use increased in June and subsequently decreased until October. In 1974, use increased in June and again in July before decreasing until October.

Vaccinium myrtilus was the ninth and eighth most preferred plant in 1973 and 1974 respectively. Occurrence in the faeces in 1973 was greatest between May and September and in 1974 from April to August with a second peak in November and December in the latter year.

Erica tetralix was the tenth most preferred species in 1973 and the twelfth in 1974. The mean occurrence in 1973 just exceeded the trace limit. In 1974 it was below this level.

The monthly occurrences of Picea abies in the faeces was below the trace level except in February 1973 and February, March, May and June in 1974. Nevertheless, this species was the eleventh and ninth most preferred plant in the annual diet of 1973 and 1974 respectively.

The remaining trees, Betula, Fagus and Ilex each had trace values in each month and annual preference ratings considerably lower than those for Picea.

The remaining grasses and grasslike plants each had mean occurrences in the faeces at or below the trace level, except Festuca, Agrostis and Deschampsia in each year, and Dactylis in 1974. The proportion of grasses and grasslike plants in faeces was generally greatest between March and July.

Pteridium was used in trace amounts in each month of 1973 and in the first six months of 1974, but it had a peak occurrence of 7.7% in August of the latter year. Although it had a higher preference rating in 1974 than in 1973, it remained an unpreferred plant.

Herbs occurred in the faeces, mainly from April to October. Oxalis and Galium were the only herbaceous species to have mean values above the trace level in each year. Annual preference ratings for herbs were generally low.

The mosses generally had mean proportions below the trace level in each year. However, Mnium had a peak occurrence of 3% in May 1974. Preference ratings were similar to those for herbs.

Table 29. Monthly occurrence as a percentage of plant species in the faeces during 1973.

Plant Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
TREES												
Fagus sylvatica	0	0	0	0	0	0	0	0	0	0	0	0
Ilex aquilofium	0	0	0	0	0	0.1	0	0.1	0.3	0	0	0
Larix decidua	0	0	0	0	0	0.3	0.3	0.4	0.3	0	0	0
Picea abies	0.9	1.4	0.1	0.8	0.8	0.5	0.3	0.6	0.5	0.6	0.7	0.9
Picea sitchensis	10.7	11.2	5.9	7.0	5.4	7.5	2.1	0.7	0.6	1.3	1.4	1.9
Pinus contorta	4.3	0.8	1.3	0.9	0.3	0.5	0	0.4	0.8	0.2	3.4	6.0
Pinus sylvestris	20.0	16.7	5.5	9.7	3.3	5.5	1.6	1.9	2.1	1.9	9.4	15.7
DWARF SHRUBS												
Calluna vulgaris	42.5	52.2	51.5	43.4	47.9	42.3	52.9	57.5	58.5	64.1	58.7	47.3
Erica tetralix	0.5	0.6	0.9	1.1	1.1	0.9	0.6	0.7	1.3	2.1	2.2	1.1
Vaccinium myrtilus	1.4	1.4	1.7	1.8	4.3	5.5	3.9	3.8	3.6	1.6	0.2	0.8
GRASSES AND GRASSLIKE PLANTS												
Agrostis sp.	0.7	1.3	2.7	2.5	4.6	2.2	2.1	2.6	1.0	2.4	3.4	0.6
Anthoxanthum odoratum	0.3	0.4	0.2	5.1	0.9	0.8	0	0.3	0.4	0	0	0
Dactylis glomerata	0.5	0.5	0.2	1.1	1.5	3.0	1.2	1.8	0.9	0.6	1.8	0.7
Deschampsia sp.	0.6	1.1	2.7	2.5	3.1	0.8	2.2	0.1	0.6	1.5	1.6	0.2
Festuca sp.	1.7	2.5	4.6	3.2	3.6	3.3	3.3	1.8	1.1	1.3	3.3	0.9
Holcus sp.	1.9	1.1	11.6	6.9	10.1	2.3	1.6	1.8	1.9	9.0	4.3	3.6
Nardus stricta	0.3	0.2	0.3	0.5	0.5	0.3	0.1	0.1	0.1	0.5	0.2	0.2
Lolium perenne	0	0	0	0	0	0	0	0	0.2	0	0.4	0
Poa sp.	0.4	0.6	0.9	1.2	3.5	1.1	1.5	0.5	0.2	0.4	0.4	0
Carex sp.	0.7	0.6	0.6	1.5	0.5	0.1	0.1	0.1	0	0.4	0.2	0.2
Eriophorum vaginatum	0	0	0	0	0	0.2	0	0.1	0.1	0	0	0
Juncus sp.	1.1	0.8	0.7	2.7	1.3	0.2	0.4	1.0	0.4	0.5	0.5	0.2
Luzula sp.	2.9	2.5	3.5	5.0	4.0	2.5	1.4	3.0	1.8	2.1	5.3	6.5
HERBS												
Chamaenerion angustifolium	0.1	0	0	0.2	0.1	0	1.4	0	0	0	0	0
Galium saxatile	0.9	0.1	0.4	0.4	0.4	3.2	1.6	1.7	2.8	0.7	0	0
Lotus sp.	0	0	0	0	0.4	1.2	1.0	0.3	0.1	0.1	0	0

/continued

Table 29 cont'd.

Plant Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Plantago sp.	0	0	0	0	0	0	0.1	0	0	0	0	0
Potentilla erecta	0	0	0	0.1	0.2	0.8	2.6	1.3	0.3	0	0	0
Oxalis acetosella	0	0	0	0	0.1	1.0	1.8	0.4	0	0.4	0.1	0.2
Ranunculus sp.	0	0	0	0	0	0.9	1.6	1.3	1.4	0	0	0
Rumex sp.	0.5	0.4	0.2	0.2	0	0.6	0.5	0.4	0.1	0.1	0	0
Stellaria holostea	0	0	0	0	0	0.5	0	0.1	0	0.1	0	0.1
Trifolium sp.	0	0	0	0	0	2.4	2.2	1.6	1.1	0	0	0
Tussilaga farfara	0	0	0	0	0	0.4	2.4	0.8	0.3	0.1	0	0
FERNS												
Blechnum spicant	2.1	0.7	0.5	0.2	0.1	2.9	2.4	4.0	6.7	1.6	0.2	4.9
Dryopteris sp.	2.9	0.9	0.9	0.6	0.5	3.2	3.0	5.3	7.9	2.3	0.2	5.9
Pteridium aquilinium	0.1	0	0	0	0	0.4	0.5	0.7	0.7	0.1	0	0.2
MOSSES												
Dicranium scoparium	0	0	0	0	0	0	0	0	0	0.2	0.1	0.1
Hylocomium splendens	0.4	0.5	0.4	0.4	0.3	0.5	0.6	0.4	0.3	0.4	0.4	0.8
Mnium hornum	0.5	0.5	0.9	0	0.5	0.3	1.1	0.4	0.5	0.2	0.1	0
Plagiothecium undulatum	0.3	0.2	0.2	0.1	0.2	0.3	0.9	0.4	0.3	1.4	0.4	0.4
Polytrichium sp.	0.5	0.4	0.3	0.3	0	0.6	0.5	0.4	0.1	1.3	0.2	0.3
Sphagnum sp.	0.2	0.1	0	0.2	0.2	0.1	0	0.1	0.3	0.2	0	0
Total fragments	2167	2125	2324	2437	1924	1260	1520	1345	1399	1504	1602	1841

Table 30. Monthly occurrence as a percentage of plant species in the faeces during 1974.

Plant Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
TREES												
Betula sp.	0	0	0	0	0	0	0	0	0.3	0	0	0
Fagus sylvatica	0	0.1	0	0	0	0	0	0.3	0.2	0	0.6	0.3
Ilex aquifolium	0	0	0	0	0	0.1	0.1	0	0	0	0	0
Larix decidua	0	0	0	0	0	0.1	0.5	0.1	0	0	0	0
Picea abies	0.5	1.1	1.2	0.9	2.7	3.4	0.5	0.1	0	0.3	0.6	0.1
Picea sitchensis	2.3	9.5	4.3	4.1	1.7	5.2	7.3	0.4	0.3	2.9	3.3	6.5
Pinus contorta	5.2	1.0	2.1	0	0.3	0.8	0	0.1	0	0.5	0.2	0.9
Pinus sylvestris	26.5	8.3	12.0	4.2	0.8	3.3	3.3	0.4	0	8.1	3.8	11.8
DWARF SHRUBS												
Calluna vulgaris	47.8	54.0	50.7	47.9	34.6	33.6	46.7	51.6	68.9	67.7	62.9	49.8
Erica tetralix	0.9	0.4	0.5	0	3.3	1.5	0.7	0	0.5	0.3	0.2	0
Vaccinium myrtilus	1.5	0.1	1.0	2.4	6.5	6.4	2.5	5.1	1.2	1.0	2.5	4.1
GRASSES AND GRASSLIKE PLANTS												
Agrostis sp.	1.3	2.2	2.2	1.0	2.3	1.1	1.1	1.7	3.3	1.8	2.2	0.3
Anthoxanthum odoratum	0	0	0	0.3	0.7	0.7	0.7	0	0	0	0	0
Dactylis glomerata	0.3	0.1	0.2	0.2	0.8	0.7	0.5	0.1	0.3	0.4	0.6	0.1
Deschampsia sp.	0.4	2.6	0.9	1.0	5.6	1.1	0.4	0.4	2.5	0.4	1.0	0.3
Festuca sp.	1.3	5.4	3.0	1.8	0.7	5.7	3.6	1.7	3.0	1.5	2.2	0.7
Holcus sp.	2.2	4.6	1.9	15.0	9.6	5.6	2.9	1.9	3.6	0.8	2.6	4.4
Nardus stricta	0.1	0.4	0.1	0	0.5	0.9	0.3	0.2	0.5	0	0.3	0.1
Lolium perenne	0	0	0	0	0	0.1	0	0	0	0	0	0
Poa sp.	0.3	0.9	0	0.1	0.1	0.9	0.3	0	0.2	0.3	0.2	0
Carex sp.	0.4	0.1	2.4	2.0	2.0	0.7	0.1	0.1	0	0.1	0.3	0.2
Eriophorum vaginatum	0	0	0	0.2	0.5	1.4	0.1	0.1	0.4	0.3	0.3	0
Juncus sp.	0.6	0.4	2.2	2.6	4.1	0.7	0.3	0.2	0	0.3	0.3	0.2
Luzula sp.	5.6	5.2	5.4	9.9	8.1	4.5	3.4	1.6	1.1	3.3	5.5	2.6
HERBS												
Chamaenerion angustifolium	0	0	0	0	0.1	0.4	3.3	0.8	0.9	0	0	0
Galium saxatile	0	0	0.4	0.3	0.7	2.0	1.4	2.1	0.6	0.8	0.3	1.6
Lotus sp.	0	0	0	0	0.4	1.6	0.7	0.5	0	0	0	0.1

/continued

Table 30 cont'd.

Plant Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Oxalis acetosella	0	0	0	0	1.7	3.8	2.0	1.6	0.9	1.6	1.4	0.5
Plantago sp.	0	0	0	0	0	0	0.3	0	0	0	0	0
Potentilla erecta	0	0	0	0	0.7	2.0	0.5	0	0.9	0.5	0.3	0
Ranunculus sp.	0	0	0	0	0.1	0.5	0.9	0.2	0.7	0	0.1	0.2
Rumex sp.	0	0	0.1	0	0.9	0.5	0	0.1	0.3	0.4	0.4	0.1
Stellaria holostea	0	0	0	0	0.4	0.3	0.1	0	0	0	0	0
Trifolium sp.	0	0	0.2	0	0	1.6	1.9	0.7	0.2	0.1	0	0
Tussilaga farfara	0	0	0	0	0	1.1	0.5	0.3	0	0	0	0
Urtica dioica	0	0	0	0	0	0.7	0.7	0.1	1.7	0.4	0	0
FERNS												
Blechnum spicant	0.2	1.1	3.4	0.3	1.1	1.4	2.7	5.4	0.9	0.8	0.9	2.9
Dryopteris sp.	0.1	1.2	2.2	0.3	1.5	1.4	5.6	11.8	2.6	1.8	2.0	8.3
Pteridium aquilinium	0.1	0	0.4	0	0.1	0.4	1.9	7.7	1.8	1.8	2.0	3.3
MOSSES												
Dicranium scoparium	0.1	0.1	0.1	0.1	0.4	0.4	0.5	0	0	0.3	0.1	0
Hylocomium splendens	0.5	0.3	1.0	1.5	0.8	0.1	0.1	0.4	0.2	0.1	0.7	0.1
Mnium hornum	0.1	0	0	1.5	3.1	1.6	0.4	0.4	0.3	0	0	0.1
Plagiothecium undulatum	0.7	0.1	0.7	1.0	1.5	0.1	0.7	0.4	0.5	0.3	1.4	0.3
Polytrichium sp.	0.5	0	0.5	0.4	0.8	0.3	0	0.3	0	0.8	0.2	0.1
Sphagnum sp.	0.1	0.3	0.5	0.6	0.5	0.7	0	0.1	0.2	0	0.1	0
Total fragments	942	887	797	949	751	731	730	895	940	725	874	956

Table 31. Annual indices for 1973 of importance and preference ratings of plant species in the diet according to faecal analysis.

Plant Species	% Frequency of[a.] Occurrence	% Mean Monthly Occurrence	Importance Index	Avail-ability Factor	Preference Rating
TREES					
Fagus sylvatica	25	0	0	1	0
Ilex aquifolium	8	0	0	1	0
Larix decidua	50	0.1	5	2	2
Picea abies	100	0.7	70	1	70
Picea sitchensis	100	5.3	530	4	132
Pinus contorta	92	1.6	147	1	147
Pinus sylvestris	100	7.8	780	4	195
DWARF SHRUBS					
Calluna vulgaris	100	51.6	5160	4	1290
Erica tetralix	100	1.1	110	1	110
Vaccinium myrtilus	100	2.5	250	2	125
GRASSES AND GRASSLIKE PLANTS					
Agrostis sp.	100	2.2	220	4	55
Anthoxanthum odoratum	67	0.7	47	3	16
Dactylis glomerata	100	1.1	110	2	55
Deschampsia sp.	100	1.4	140	3[b.]	47
Festuca sp.	100	2.6	260	4	65
Holcus sp.	100	4.7	470	3	157
Nardus stricta	100	0.3	30	1	30
Lolium perenne	17	0	0	1	0
Poa sp.	100	0.9	90	3	30
Carex sp.	92	0.4	37		
Eriophorum vaginatum	34	0	0	2	0
Juncus sp.	100	0.8	80	4	20
Luzula sp.	100	3.3	330	1	330
HERBS					
Chamaenerion angustifolium	50	0.1	5	1	5
Galium saxatile	100	1.0	100	4	25
Lotus sp.	50	0.2	10	2	5

/continued

Table 31 cont'd.

Plant Species	% Frequency of Occurrence	% Mean Monthly Occurrence	Importance Index	Avail-ability Factor	Preference Rating
Plantago sp.	17	0	0	2	0
Potentilla erecta	50	0.4	20	2	10
Oxalis acetosella	67	0.3	20	2	10
Ranunculus sp.	42	0.4	17	2	8
Rumex sp.	75	0.3	22	1	22
Stellaria holostea	42	0.1	4	1	4
Trifolium sp.	34	0.7	24	2	12
Tussilaga farfara	42	0.3	13	1	13
FERNS					
Blechnum spicant	100	2.2	220	1	220
Dryopteris sp.	100	2.8	220	2	140
Pteridium aquilinium	58	0.2	280	3	4
MOSSES					
Dicranium scoparium	25	0	0	0[c]	0
Hylocomium splendens	100	0.5	50	2	25
Mnium hornum	83	0.4	33	2	16
Plagiothecium undulatum	100	0.4	40	1	40
Polytrichium sp.	100	0.4	40	2	20
Sphagnum sp.	75	0.1	7	2	3

[a] Number of months in which species occurred, expressed as a percentage

[b] Means for *Deschampsia caespitosa* and *D. flexuosa* together

[c] Not recorded during vegetation sampling.

Table 32. Annual indices for 1974 of importance and preference ratings of plant species in the diet according to faecal analysis.

Plant Species	% Frequence of[a] Occurrence	% Mean Monthly Occurrence	Importance Index	Avail-ability Factor	Preference Rating
TREES					
Betula sp.	8	0	0	2	0
Fagus sylvatica	42	0.1	4	1	4
Ilex aquifolium	17	0	0	1	0
Larix decidua	25	0	0	2	0
Picea abies	92	0.9	83	1	83
Picea sitchensis	100	4.0	400	4	100
Pinus contorta	75	0.9	67	1	67
Pinus sylvestris	92	6.9	635	4	159
DWARF SHRUBS					
Calluna vulgaris	100	51.4	5140	4	1285
Erica tetralix	75	0.7	52	1	52
Vaccinium myrtilus	100	2.8	280	3	93
GRASSES AND GRASSLIKE PLANTS					
Agrostis sp.	100	1.7	170	4	42
Anthoxanthum odoratum	33	0.2	6	3	2
Dactylis glomerata	100	0.4	40	2	20
Deschampsia sp.	100	1.4	140	3[b]	47
Festuca sp.	100	2.5	250	4	62
Holcus sp.	100	4.6	460	4	115
Nardus stricta	92	0.3	28	1	28
Lolium perenne	8	0	0	1	0
Poa sp.	75	0.3	22	3	7
Carex sp.	92	0.7	64	2	32
Eriophorum vaginatum	67	0.3	20	2	10
Juncus sp.	92	1.0	92	4	23
Luzula sp.	100	4.7	470	2	235
HERBS					
Chamaenerion angustifolium	42	0.5	21	1	21
Galium saxatile	84	0.8	67	4	17

/continued

Table 32 cont'd.

Plant Species	% Frequency of Occurrence	% Mean Monthly Occurrence	Importance Factor	Availability Factor	Preference Rating
Lotus sp.	33	0.3	9	2	4
Oxalis acetosella	67	1.2	74	2	37
Plantago sp.	8	0	0	2	0
Potentilla erecta	50	0.8	40	2	20
Ranunculus sp.	58	0.2	12	1	12
Rumex sp.	67	0.2	13	2	6
Stellaria holostea	25	0.1	2	2	1
Trifolium sp.	50	0.4	20	2	10
Tussilaga farfara	33	0.2	7	1	7
Urtica dioica	42	0.3	13	3	4
FERNS					
Blechnum spicant	100	1.8	180	1	180
Dryopteris sp.	100	3.2	320	2	160
Pteridium aquilinium	83	1.6	133	4	33
MOSSES					
Dicranium scoparium	75	0.2	15	0[c]	0
Hylocomium splendens	100	0.5	50	2	25
Mnium hornum	67	0.6	40	2	20
Plagiothecium undulatum	100	0.6	60	3	20
Polytrichium sp.	75	0.3	22	3	7
Sphagnum sp.	75	0.3	22	3	7

a. b. and c. As Table 31.

4.3.4 Seasonal Variation in the Plant Group Composition of Deer Faeces

The seasonal mean percentage occurrences of plant groups in the faeces are illustrated in Fig. 14. These data were tested for differences among seasonal means within plant groups using the SNK test (Table 33).

The trends in the proportions of tree browse in the faeces were the same in each year. Occurrences decreased from winter to summer and then increased through autumn to winter. Use in each year was significantly higher ($P < 0.05$) in winter than in summer.

Use of dwarf shrubs decreased from winter to spring but increased as summer progressed. A slight decrease occurred from summer to autumn in 1973, but the reverse happened in 1974. However, the differences were not significant ($P > 0.05$) both among seasons and between years.

Occurrences of grasses and grasslike plants peaked in spring in each year and decreased in summer. There was a further increase in use in the autumn of 1973 but a slight decrease in that of 1974. The proportion in the spring of 1974 was significantly higher ($P < 0.05$) than that in all other seasons, except spring 1973.

Peak use of herbs was in the summer in each year. Occurrences were not significantly ($P > 0.05$) different with the exception of use in the summer of 1973 and 1974, being each significantly greater than that in the winter of 1974.

Use of ferns increased in each year from spring to summer and then decreased from summer to autumn. The difference between the two summers was not significant, but use in each summer was significantly higher ($P < 0.05$) than that in the other seasons.

Mosses had the lowest level of occurrence in the faeces. Use in 1973 increased from spring to summer, then decreased. In 1974, occurrence increased from winter to spring with use at this time being significantly higher ($P < 0.05$) than that in all other seasons.

The seasonal plant group data were initially analysed for each year

Fig. 14. Changes in faecal composition with season during 1973 and 1974

W = Winter, Sp = Spring, S = Summer, A = Autumn

Dwarf shrubs

Trees

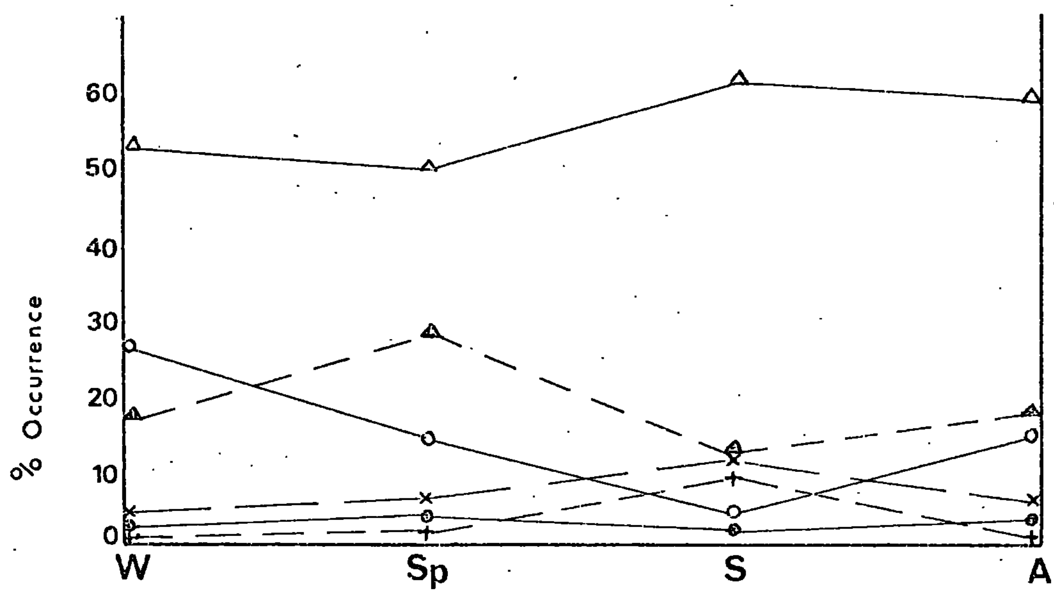
Grasses and Grasslike Plants

Herbs

Ferns

Mosses

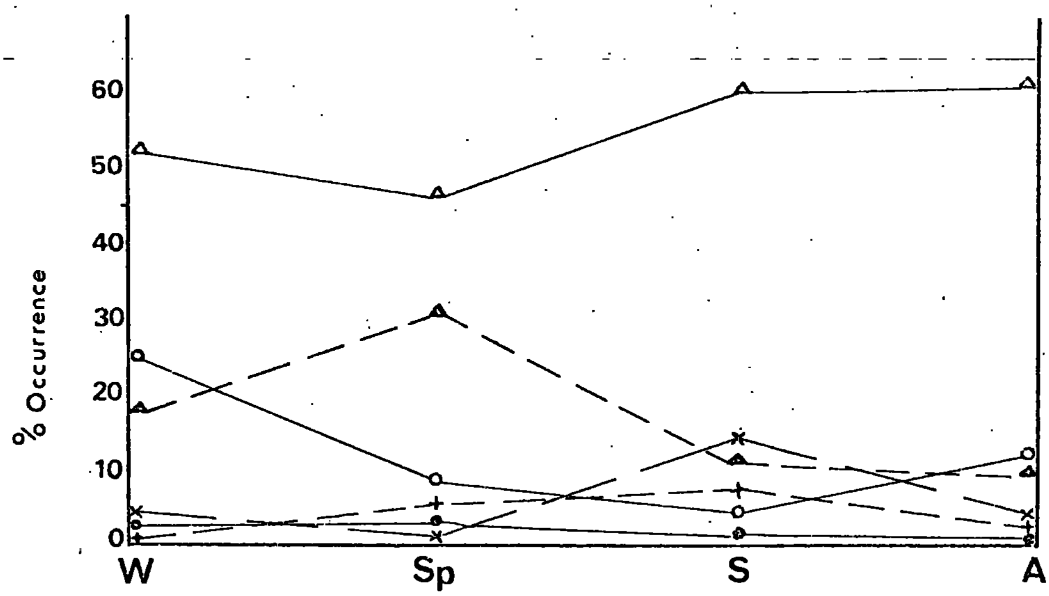
a.



% Occurrence
0
10
20
30
40
50
60
W
Sp
S
A

1973

b.



% Occurrence
0
10
20
30
40
50
60
W
Sp
S
A

1974

Table 33. Multiple comparisons of the seasonal mean occurrences of individual plant groups in faeces during 1973 and 1974.

Trees

	Summer 1974	Summer 1973	Spring 1974	Autumn 1974	Autumn 1973	Spring 1973	Winter 1974	Winter 1973
Rank:	1	2	3	4	5	6	7	8
Mean:	11.72	12.01	17.41	21.07	21.40	22.00	24.63	30.36

Dwarf Shrubs

	Spring 1974	Spring 1973	Winter 1973	Winter 1974	Summer 1974	Autumn 1973	Summer 1973	Autumn 1974
Rank:	1	2	3	4	5	6	7	8
Mean:	42.33	44.67	45.53	46.30	50.30	50.44	51.28	52.47

Grasses and Grasslike Plants

	Autumn 1974	Summer 1973	Summer 1974	Winter 1973	Winter 1974	Autumn 1973	Spring 1973	Spring 1974
Rank:	1	2	3	4	5	6	7	8
Mean:	19.43	20.18	20.28	23.74	24.74	24.80	31.46	33.82

Herbs

	Winter 1974	Autumn 1973	Winter 1973	Autumn 1974	Spring 1973	Spring 1974	Summer 1974	Summer 1973
Rank:	1	2	3	4	5	6	7	8
Mean:	1.64	3.90	5.80	9.97	10.72	12.88	16.75	17.87

/continued

Table 33 cont'd.

Ferns

	Spring 1974	Spring 1973	Winter 1974	Winter 1973	Autumn 1973	Autumn 1974	Summer 1973	Summer 1974
Rank:	1	2	3	4	5	6	7	8
Mean:	7.98	8.14	8.92	9.11	11.65	15.75	18.55	20.66

Mosses

	Spring 1973	Autumn 1974	Summer 1974	Winter 1973	Winter 1974	Summer 1973	Autumn 1973	Spring 1974
Rank:	1	2	3	4	5	6	7	8
Mean:	6.70	6.87	7.39	7.49	7.83	8.24	8.44	12.95

Differences which are not significant at P = 0.05 are underlined.

Table 34. Two way anova of plant groups occurring in the faeces of deer during 1973.

Source of Variation	d.f.	S.S.	M.S.	F_s.
Seasons	3	16.76	5.58	0.02[n.s.]
Plant Groups	5	13594.56	2718.91	118.50[1.]
Seasons x Plant Groups (Interaction)	15	1345.45	89.69	3.91[1.]
Error	48	1101.34	22.94	
Total	71			

[1.] Significant at P = 0.01

[n.s.] Not significant at P = 0.05

Table 35. Two way anova of plant groups occurring in the faeces of deer during 1974.

Source of Variation	d.f.	S.S.	M.S.	F_s.
Seasons	3	21.46	7.15	0.33[n.s.]
Plant Groups	5	12692.59	2538.52	117.21[1.]
Seasons x Plant Groups (Interaction)	15	1853.52	123.57	5.71[1.]
Error	48	1039.10	21.65	
Total	71			

[1.] Significant at P = 0.01

[n.s.] Not significant at P = 0.05

separately using a two anova with replication as shown in Tables 34 and 35. These analyses indicated that there were significant ($P < 0.01$) differences in the proportions of plant groups in the faeces, that the occurrence of a given plant group did not differ significantly between seasons, although the interaction factor was significant ($P < 0.01$).

The SNK test was used to find out between which plant groups differences were significant (Tables 36 and 37). The order of ranking of the different plant groups was identical in both winters. The ranking order in the spring changed from that of the immediately preceding winter, in both years. Furthermore, the order of the first three plant groups was different in the two springs. The ranking order changed again in the summer of both years. Except for the positions of ferns and grasses and grasslike plants in 1973 being reversed in 1974, the order of ranking was the same in both summers. Again, in each autumn, the ranking order of the plant groups differed both from the preceding season and the other year. Dwarf shrubs, as in previous seasons, comprised a significantly ($P < 0.05$) higher proportion of the faeces than did other plant groups; the only exception was in the spring of 1973 when the use of dwarf shrubs did not differ from that of grasses and grasslike plants.

Further analyses using a two-way anova with replication (Table 38) indicated that the proportion of an individual plant group in a given season of 1974 did not differ from its level of use in the same season of 1973 but the proportion did differ significantly ($P < 0.05$) from the occurrence of other plant groups. There was no evidence of a plant group, year interaction effect.

No SNK test was conducted, although the overall anova indicated significant differences in the occurrence of individual plant groups because to have done so would have entailed some repetitions and, in any case, significant differences can be inferred from the analyses of Tables 33, 36 and 37.

Table 36. Multiple comparisons of the mean occurrence of plant groups in faeces within seasons in 1973.

Winter

	Herbs	Mosses	Ferns	Grasses and Grasslike Plants	Trees	Dwarf Shrubs
Rank:	1	2	3	4	5	6
Mean:	5.81	7.49	9.12	23.74	30.36	45.53

Spring

	Mosses	Ferns	Herbs	Trees	Grasses and Grasslike Plants	Dwarf Shrubs
Rank:	1	2	3	4	5	6
Mean:	6.71	8.14	10.72	22.00	31.46	44.68

Summer

	Mosses	Trees	Herbs	Ferns	Grasses and Grasslike Plants	Dwarf Shrubs
Rank:	1	2	3	4	5	6
Mean:	8.25	12.01	17.87	18.55	20.19	51.28

Autumn

	Herbs	Mosses	Ferns	Trees	Grasses and Grasslike Plants	Dwarf Shrubs
Rank:	1	2	3	4	5	6
Mean:	3.90	8.44	11.65	21.40	24.8	52.48

Differences which are not significant at P = 0.05 are underlined

Table 37. Multiple comparisons of the mean occurrences of plant groups in faeces within seasons in 1974.

Winter

	Herbs	Mosses	Ferns	Grasses and Grasslike Plants	Trees	Dwarf Shrubs
Rank:	1	2	3	4	5	6
Mean:	1.64	7.84	8.92	24.74	29.63	46.30

Spring

	Ferns	Herbs	Mosses	Trees	Grasses and Grasslike Plants	Dwarf Shrubs
Rank:	1	2	3	4	5	6
Mean:	7.98	12.88	12.95	17.41	33.82	42.33

Summer

	Mosses	Trees	Herbs	Grasses and Grasslike Plants	Ferns	Dwarf Shrubs
Rank:	1	2	3	4	5	6
Mean:	7.39	11.12	16.75	20.29	20.67	50.30

Autumn

	Mosses	Herbs	Ferns	Grasses and Grasslike Plants	Trees	Dwarf Shrubs
Rank:	1	2	3	4	5	6
Mean:	6.87	9.97	15.75	19.43	21.07	52.48

Differences which are not significant at P = 0.05 are underlined

Table 38. Two way anova of the occurrence of plant groups in faeces within seasons between years.

	Winter 1973, 1974			
Source of Variation	d.f.	S.S.	M.S.	$F_{S.}$
Years	1	2.22	2.2	$0.11^{n.s.}$
Plant Groups	5	7963.35	1592.67	$82.43^{1.}$
Years x Plant Groups (Interaction)	5	27.20	5.44	$0.28^{n.s.}$
Error	24	463.71	19.32	
Total	35			
	Spring 1973, 1974			
	d.f.	S.S.	M.S.	$F_{S.}$
Years	1	3.76	3.76	$0.15^{n.s.}$
Plant Groups	5	6123.01	1224.60	$45.52^{1.}$
Years x Plant Groups (Interaction)	5	109.95	21.99	$0.89^{n.s.}$
Error	24	593.46	24.72	
Total	35			
	Summer 1973, 1974			
	d.f.	S.S.	M.S.	$F_{S.}$
Years	1	0.81	0.81	$0.03^{n.s.}$
Plant Groups	5	6982.66	1396.53	$68.19^{1.}$
Years x Plant Groups (Interaction)	5	12.80	2.56	$0.12^{n.s.}$
Error	24	491.49	20.47	
Total	35			
	Autumn 1973, 1974			
	d.f.	S.S.	M.S.	$F_{S.}$
Years	1	6.07	6.07	$0.24^{n.s.}$
Plant Groups	5	8140.16	1628.03	$66.81^{1.}$
Years X Plant Groups (Interaction)	5	127.75	25.55	$1.04^{n.s.}$
Error	24	584.76	24.36	
Total	35			

$^{1.}$Significant at P = 0.01

$^{n.s.}$Not significant at P = 0.05

4.3.5 Winter Diet of Sheep Determined from Analysis of Faeces

Sheep faeces were analysed for the first three months of 1974 only. A total of 33 plant species was identified in these faeces, made up of seven trees, three dwarf shrubs, three herbs, 12 grasses and grasslike plants, two ferns and six mosses. The percentage occurrences of the plant species in the faeces at this time are given in Table 39, and indices of importance and preference ratings given in Table 40.

The most preferred plant was Luzula. Calluna, which was the most important and most heavily used species, was the second most preferred food. Vaccinium was the third and Festuca the fourth most preferred species, both with mean occurrences only slightly less than that of Luzula, followed in sequence by Deschampsia, Holcus, Agrostis, Nardus, Pinus sylvestris and Carex. The remaining species of trees, dwarf shrubs, grasses and grasslike plants except Juncus, herbs, ferns and mosses occurred in trace proportions only. Of these remaining species, Dryopteris and Blechnum were the most preferred.

The percentage occurrences of the different plant groups in the faeces are illustrated in Fig. 15a. For comparison, the plant group composition of deer faeces for the same period is shown in Fig. 15b. Statistical comparisons of the plant group composition of the faeces of these species are given in Tables 42 and 43. A SNK test has been used here to detect between which plant groups in the sheep faeces differences are significant (Table 41).

Grasses and grasslike plants were the most heavily used plant group (Fig. 15a) with its proportion of the faeces being significantly higher ($P < 0.05$) than that of all other plant groups, except dwarf shrubs. This latter group was the second most heavily used. Use of the remaining plant groups was low and their occurrences were not significantly different ($P > 0.05$) from one another.

The plant group data for sheep and deer were compared in a two way

Table 39. Monthly occurrence of plant species expressed as percentages in the faeces of sheep during the winter of 1974.

Plant Species	Jan.	Feb.	March
TREES			
Fagus sylvatica	0	0	0.1
Ilex aquifolium	0.1	0.5	0
Larix decidua	0	0	0.1
Picea abies	0	0	0.7
Picea sitchensis	0.1	0	1.6
Pinus contorta	0.5	0.4	0
Pinus sylvestris	3.5	2.6	5.5
DWARF SHRUBS			
Calluna vulgaris	17.6	38.9	17.6
Erica tetralix	0.1	0	0
Vaccinium myrtilus	26.2	11.2	1.8
GRASSES AND GRASSLIKE PLANTS			
Agrostis sp.	3.9	3.3	7.7
Anthoxanthum odoratum	0	0	0.2
Dactylis glomerata	0.5	0.8	0.6
Deschampsia sp.	4.7	6.7	8.1
Festuca sp.	14.5	10.1	18.1
Holcus sp.	6.7	5.3	6.6
Nardus stricta	1.2	0.9	0.8
Poa sp.	0.2	0.2	0.7
Carex sp.	1.5	2.8	0.3
Eriophorum vaginatum	0.2	0	0
Juncus sp.	1.1	1.1	1.6
Luzula sp.	16.2	12.9	17.6
HERBS			
Galium saxatile	0	0	0.2
Ranunculus sp.	0	0	0.1
Trifolium sp.	0	0	0.2

/continued

Table 39 cont'd.

Plant Species	Jan.	Feb.	March
FERNS			
Blechnum spicant	0.1	0	1.6
Dryopteris sp.	0.2	0.4	2.0
MOSSES			
Dicranium scoparium	0.1	0.2	1.1
Hylocomium splendens	0	0.5	0.9
Mnium hornum	0	0	0.3
Plagiothecium undulatum	0.2	0.3	2.0
Polytrichium sp.	0	0.5	1.0
Sphagnum sp.	0	0.1	0.6

Table 40. Indices of importance and preference ratings of plant species in the 1974 winter diet of sheep according to faecal analysis.

Plant Species	% Frequency of[a] Occurrence	% Mean Monthly Occurrence	Importance Index	Availability Factor	Preference Rating
TREES					
Fagus sylvatica	33	0	0	1	0
Ilex aquifolium	67	0.2	13	1	13
Larix decidua	33	0	0	2	0
Picea abies	33	0.2	7	1	7
Picea sitchensis	67	0.6	40	4	10
Pinus contorta	67	0.3	20	1	20
Pinus sylvestris	100	3.8	380	4	95
DWARF SHRUBS					
Calluna vulgaris	100	24.7	2470	4	617
Erica tetralix	33	0	0	1	0
Vaccinium myrtilus	100	13.1	1310	3	436
GRASSES AND GRASSLIKE PLANTS					
Agrostis sp.	100	5.0	500	4	125
Anthoxanthum odoratum	33	0.1	3	3	1
Dactylis glomerata	100	0.6	60	2	30
Deschampsia sp.	100	6.5	650	3[b]	250
Festuca sp.	100	14.2	1420	4	355
Holcus sp.	100	6.2	620	4	155
Nardus stricta	100	1.0	100	1	100
Poa sp.	100	0.4	40	2	20
Carex sp.	100	1.4	140	3	47
Eriophorum vaginatum	33	0.1	3	2	1
Juncus sp.	100	1.2	120	4	30
Luzula sp.	100	15.6	1560	2	780
HERBS					
Galium saxatile	33	0.1	3	4	1
Ranunculus sp.	33	0	0	1	0
Trifolium sp.	33	0.1	3	2	1

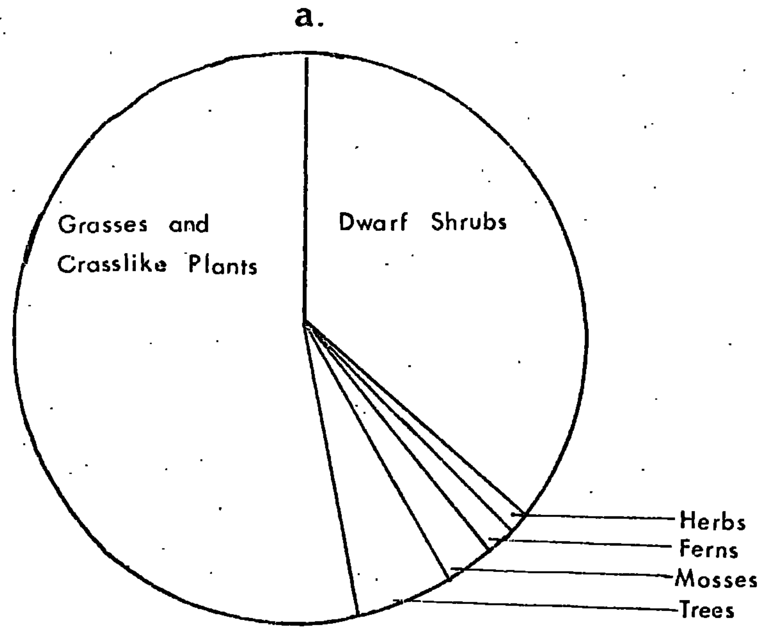
/continued

Table 40 cont'd.

Plant Species	% Frequency of Occurrence	% Mean Monthly Occurrence	Importance Index	Availability Factor	Preference Rating
FERNS					
Blechnum spicant	67	0.6	40	1	40
Dryopteris sp.	100	0.9	90	2	45
MOSSES					
Dicranium scoparium	100	0.4	40	0[c.]	0
Hylocomium splendens	67	0.3	20	1	20
Mnium hornum	33	0.1	3	2	1
Plagiothecium undulatum	100	0.8	80	3	27
Polytrichium sp.	67	0.3	20	3	7
Sphagnum sp.	67	0.2	13	2	6

[a.b.c.] See Table 31.

Fig. 15. Plant group composition of (a) sheep faeces and (b) deer faeces in the winter of 1974.


a.
Grasses and Crasslike Plants
Dwarf Shrubs
Herbs
Ferns
Mosses
Trees

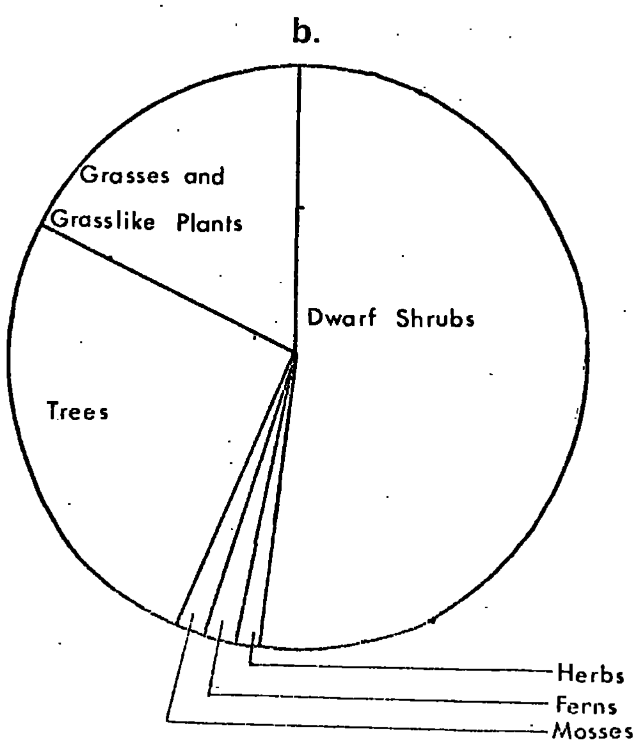

b.
Grasses and Grasslike Plants
Dwarf Shrubs
Trees
Herbs
Ferns
Mosses

Table 41. Multiple comparisons of the occurrences of plant groups in the faeces of sheep during the winter of 1974.

	Herbs	Ferns	Mosses	Trees	Dwarf Shrubs	Grasses and Grasslike Plants
Rank:	1	2	3	4	5	6
Mean:	1.44	6.03	8.92	13.01	37.59	46.39

Differences which are not significant at P = 0.05 are underlined.

Table 42. Two way anova of the occurrence of plant groups in the faeces of sheep and deer during the winter of 1974.

Source of Variation	d.f.	S.S.	M.S.	F_s
Species (Sheep, Deer)	1	8.05	8.05	0.36[n.s.]
Plant groups	5	8135.63	1627.12	72.15[1.]
Species x Plant groups (Interaction)	5	1237.53	247.50	10.58[1.]
Error	24	541.23	22.55	
Total	35			

[1.] Significant at P = 0.01

[n.s.] Not significant at P = 0.05

Table 43. Multiple comparisons of the occurrences of plant groups in the faeces of sheep and deer in the winter of 1974.

Animal Species:	Sheep	Deer	Sheep	Deer	Deer	Sheep	Sheep	Deer	Deer	Sheep	Deer	Sheep
Plant Group:	Herbs	Herbs	Ferns	Mosses	Ferns	Mosses	Trees	Grasses[a]	Trees	Dwarf[b]	Dwarf	Grasses
Rank:	1	2	3	4	5	6	7	8	9	10	11	12
Mean:	1.44	1.64	6.03	7.84	8.92	8.92	13.01	24.74	29.63	37.59	46.30	46.39

Differences not significant at $P = 0.05$ are underlined.

[a] Grasses and Grasslike Plants

[b] Dwarf Shrubs

anova with replication (Table 42). This analysis indicated that the plant group composition of sheep and deer faeces did not differ significantly, but that there were significant differences ($P < 0.05$) between the occurrences of individual plant groups in the faeces of both species. There was a significant ($P < 0.05$) effect on the proportions of plant groups in the faeces of each species due to a sheep, deer plant group interaction.

The SNK test was used to detect between which plant groups means were significantly different (see Tables 43, Figs 15 a, b. and Table 41).

The occurrence of grasses and grasslike plants was significantly ($P < 0.05$) higher in sheep faeces than in those of deer and the proportion of dwarf shrubs in sheep faeces was not significantly ($P > 0.05$) different from that in deer. The proportions of these two plant groups did not differ significantly in sheep faeces, but did so in deer. The proportions of ferns, mosses and herbs in the faeces of the two species did not differ significantly, but tree browse had a significantly ($P < 0.05$) higher occurrence in deer faeces.

4.3.6 Estimation of Plant Abundance and Use in Westmoor Plantation

The dry weights of plant species clipped from both inside and outside the exclosures are given for each habitat in Table 44. There was little difference in the total amount of vegetation clipped from inside and outside the exclosures. The data in Table 44 suggest that available vegetation was most abundant in the plantation habitat followed, in decreasing order of abundance, by the rides, fir spruce, larch, birch pine and Scots pine types. In the exclosures *Pteridium* was the species present in the greatest amount, with grasses and grasslike plants as a group, *Calluna* and *Deschampsia flexuosa* the next most abundant respectively, whereas in the open plots, grasses and grasslike plants, *Calluna*, *Deschampsia flexuosa* and *Pteridium* were the most abundant respectively.

There was no obvious sign of grazing by the deer in any of the open

Table 44. Amount of vegetation in g./m². clipped from enclosed plots (E) and open plots (O) in individual habitats.

Plant Species		Birch Pine	Scots Pine	Larch	Fir Spruce	Plantation	Rides	Total
Pinus sylvestris	E	0	0.3	0	0	2.6	0	2.9
	O	0	0.3	0	0	1.4	0	1.7
Picea sitchensis	E	0	0	0	0	1.8	0	1.8
	O	0	0	0	0	1.6	0	1.6
Picea abies	E	0	0	0	0.2	0	0	0.2
	O	0	0	0	0.5	0	0	0.5
Larix decidua	E	0	0	0.8	0	0	0	0.8
	O	0	0	0.3	0	0	0	0.3
Pseudostuga menziesii	E	0	0	0	5.9	0	0	5.9
	O	0	0	0	5.5	0	0	5.5
Betula sp.	E	0	0	0.2	0	2.2	0	2.4
	O	0	0	0	0	1.2	0	1.2
Calluna vulgaris	E	0	0	0	0.7	2.6	10.0	13.3
	O	0	0	0	1.8	4.0	12.0	17.8
Erica tetralix	E	0	0	0	0	0.8	0	0.8
	O	0	0	0	0	0	0	0
Vaccinium myrtilus	E	0	0.7	0.3	0	0	1.6	2.6
	O	0.1	0.3	0.1	0	0	0.5	1.0
Grasses and Grasslike Plants[a]	E	1.5	0	2.7	3.0	8.0	2.0	17.2
	O	1.6	0	2.8	2.5	12.2	1.5	20.6
Deschampsia flexuosa	E	3.1	1.9	2.0	0.9	2.4	1.6	11.9
	O	4.1	2.1	1.9	1.8	2.8	2.0	14.7
Holcus sp.	E	0.5	0	0	0	0	0	0.5
	O	0.4	0	0	0	0	0	0.4
Galium saxatile	E	0.2	0	0	0	0	0.1	0.3
	O	0	0	0	0	0	0	0
Oxalis acetosella	E	0.2	0	0	0	0	0	0.2
	O	0.2	0	0	0	0	0	0.2
Pteridium aquilinium	E	1.3	0	2.1	3.9	5.8	7.1	20.2
	O	0.4	0	4.0	1.1	4.6	3.9	14.0
Sphagnum sp.	E	0	0	0	4.3	0	0	4.3
	O	0	0	0	3.0	0	0	3.0
Other Mosses	E	0	0	0.3	1.1	0	0	1.4
	O	0	0	0.2	1.4	0	0	1.6
Total	E	6.8	2.9	8.4	20.0	26.2	22.4	86.7
	O	6.8	2.7	9.3	17.6	27.8	19.9	84.1

Habitat Types: Birch Pine, Scots Pine, Larch, Fir Spruce, Plantation, Rides, Total.

[a] Only those grasses and grasslike plants which could not be identified to species are included in this group.

plots. However, some young Pinus sylvestris and Betula growing in the plantation away from the open plots there, had been heavily browsed.

4.4 Discussion

Changes in the composition of the rumen contents and faeces with season reflect changes in plant availability and in plant preferences of the deer. The heavy use of herbs in spring and summer and of grasses and grasslike plants in spring could be accounted for by the improved nutritive quality of these foods at these times, since young growing shoots are usually more nutritious than mature ones (Dietz 1965). Selection of the most nutritious food has been reported for deer by Swift (1948) and Klein (1970), for sheep and cattle by Bedell (1971) and Thetford, Pipier and Nelson (1971) and for Lagopus mutus (Icelandic ptarmigan) by Gardarsson and Moss (1970). Selection however, is not always related to nutritive quality, since plants not selected are often as nutritious as those which are (Longhurst, Oh, Jones and Kepner 1968). Sheep are known to select food of higher nutritive value than cattle (Bedell 1971, Theford et al 1971).

Heavy use of browse by roe deer has been reported previously by Juon (1963), Siuda et al (1969) and by Hosey (1974). According to Juon (1963) coarse fibrous material, or ballast, is important to roe in all seasons, and must be present if the movement of the food and regulation of digestion in the intestine is to be normal. This material is obtained mostly by browsing. On an annual average browse constitutes 60% or more of the weight of the material ingested. This indicates that the structural and mechanical properties of food can be as important as nutrient content (Juon 1963). Calluna, the principal food of the roe in Hamsterley, is high in fibre and low in protein (Moss and Parkinson 1972).

Very little work has been done on the diet of roe deer inhabiting habitats similar to those in Hamsterley elsewhere in Britain. The winter diet of roe living in conifer forests in western Argyll was determined from rumen contents analysis by Hosey (1974). He found the main foods of the deer in these forests as a whole to be Calluna, Picea, grasses, Vaccinium and Corylus. The composition of the diet was thus similar to that of the winter diet of the Hamsterley deer, with the following exceptions. Firstly, Corylus was never identified in rumen samples from Hamsterley deer, since Corylus is absent from or occurs only rarely in the forest, and secondly, Pinus sylvestris was a more preferred food at Hamsterley than Picea. This similarity of winter diet in the two areas reflects a similarity of available vegetation at Hamsterley and in the western Argyll forests.

In Chedington Wood, Dorset where the vegetation differs from that at Hamsterley, Hosey (1974) using faecal analysis found Rubus fructicosus to be the main winter food and to constitute over 50% of the annual diet. Calluna forms a similar proportion of the annual diet of the Hamsterley deer, according to faecal analysis. Robertson (1967) using the feeding minutes method, reported that roe in Caedmuir Forest, Peebles in winter, fed mostly on grasses (of which Holcus lanatus was the most important), Calluna, Larix, Chamaenerion and Pinus sp. respectively. Faecal analysis indicated Holcus to be the most preferred grass in the annual diet of the Hamsterley deer with peak use from March to May. In these months, the deer at Caedmuir were utilising mostly young Calluna shoots and Chamaenerion (Robertson 1967), which were also important foods of the Hamsterley deer in spring.

Chamaenerion was highly preferred in summer by the deer, both at Hamsterley and Caedmuir. In autumn at Hamsterley however, there was a shift towards browse and Calluna in particular, whereas at Caedmuir heavy use of Chamaenerion continued and use of grasses, and hips of Rosa sp. became prominent (Robertson 1967). Robertson also reported that Betula sp. was heavily used. At Hamsterley, although birch was an unimportant food, it was heavily browsed in some, but not all, parts of the forest where it occurred. This browsing could have been preventing regeneration locally. This observation suggests that local differences in food preferences may exist, but as the data have shown, these differences are often insufficient to influence significantly the overall composition of the diet.

Rumen contents and faecal analysis both indicated that Calluna was the most preferred shrub and plant in the diet as a whole. The latter method suggested a considerably higher seasonal and annual intake of Calluna than the former method. This could be attributed to a higher degree of selection of this food in the study area, where faeces were collected, than elsewhere in the forest from where samples of rumen contents were mostly collected; or to Calluna being proportionately more abundant within the study area than over the forest as a whole, with the result that deer using the study area ate more Calluna there than elsewhere. Alternatively, Calluna might be more resistant to digestion than all other plants, thus causing faecal analysis to indicate a higher level of use of Calluna than actually occurred. In contrast, rumen contents analysis indicated the intake of Pinus sylvestris to be about twice the level suggested by faecal analysis. The possibility of this being a reflection of this species being much less abundant in the study area than in the forest as a whole, is supported by the impression that it in fact appears to be more abundant outside of the study area. Since rumen contents were mostly collected outside of the study area, more Pinus sylvestris might therefore occur in the samples of rumen contents than in the faeces.

The differences in the values given by these two methods for the occurrences of the other browse species are less marked, and in many cases, slight. Both methods indicated that mosses were little used, and likewise ferns. However, in comparison with their availability, the annual preferences of Blechnum and Dryopteris were high. Only the leaves of the latter species were present in the rumen contents and faeces of roe from Hamsterley, whereas at Glentress Forest, rhizomes of Dryopteris sp. are apparently the main winter food (A. Louden pers. comm.). Fungi which are a relatively minor food of deer, although frequently eaten in small quantities (Siuda et al 1969, Hosey 1974) were identified only in rumen contents. A disadvantage of the analysis of rumen contents is that in contrast to faecal analysis, grasses and grasslike plants could not be identified to species level.

Rumen contents analysis indicated Chamaenerion to occur in greater proportions in the spring and summer diets than did faecal analysis, whereas the proportion of these diets which each of the other herbs comprised was similar according to both methods. It is unlikely that samples of rumen contents were obtained from deer in areas where Chamaenerion was more abundant than in the study area since some of the samples of rumen contents were collected from deer shot in the study area in spring and summer. It is possible that Chamaenerion almost totally disintegrates during the digestive process resulting in its under-representation in the faeces. This view would imply that Chamaenerion is more completely digested than other herbs ingested, where the occurrences in rumen contents and in the faeces were generally similar.

Precise comparisons of the findings from examination of rumen contents with those from faecal analysis are, however, not strictly legitimate because the samples of rumen contents which were assumed to be representative of the seasonal diets, were taken on only a few days in each of the months of a given season. Faecal analysis in contrast, represented a more continuous monitoring of the monthly, seasonal and annual diet and, furthermore, provided data which were representative of the study area and its immediate surroundings, whereas the rumen contents were obtained from deer shot anywhere in the forest. A further complication is the fact that since rumen contents analysis is a gross analytical technique, based on large plant fragments and faecal analysis is a microscopic one based on identification of considerably smaller fragments, the two methods may indicate different values for the proportions of individual plants in any given diet. I would suggest that in a future evaluation of the two methods, comparisons be made of the results of the point frame method with those from the microscopic analyses of rumen contents and faeces of the same animal (see Todd and Hansen 1973, Anthony and Smith 1974). Of course, any differences in the results obtained from using these methods can be partially explained on the basis of 'throughput time', which is the period between ingestion to the time of elimination of a particular food item. For example, what a deer ate a few hours prior to collection as shown in a sample of rumen contents, may differ from what it ate 24 to 120 hours (throughput time) before collection and shown in faecal samples (Anthony and Smith 1974). The complication of throughput time would be resolved if the animals had been feeding on a constant diet for 120 hours. The above type of work could provide the basis for calculation of a correction factor (Neal, Pulkinen and Owen 1973) for certain plant species, thus enabling even greater reliance to be placed upon diet determined for wild animals by faecal analysis.

The large intake of grasses and grasslike plants by sheep in winter was expected, since sheep are primarily grazers. But although used to a lesser extent than by the deer, Calluna was nevertheless the most common species in the sheep diet. Colquhoun (1971) noted that sheep occupying the same range as Cervus elaphus in Perthshire had similarly a higher intake of grasses and grasslike plants than the deer. McDougall (1972, 1975) noted considerable overlap in the diet of sheep and goats (Capra hircus) in late spring and early summer on Kielderhead Moor. Calluna was the main food of both species there, although the sheep made greater use of Festuca than the goats. In using grasses, the sheep are selecting a food of higher quality, since grass apparently has a higher digestible energy and protein content than Calluna (see Colquhoun 1971, Miller 1971). At Hamsterley, Vaccinium was more heavily used by the sheep than by the deer, although still to a lesser extent than Calluna, and Vaccinium was observed to be heavily browsed in areas where sheep congregated. Similar work needs to be done over the year as a whole before the magnitude of possible competition between roe deer and sheep for food plants in the forest can be determined.

In the clipping study, the fact that differences between the total weights of vegetation clipped from inside and outside the exclosures was so small suggests that feeding pressure in the wood was light. The plant indicated to be the main food by this technique in summer was not the same as that indicated by the analysis of faeces and rumen contents. The latter methods considered together indicated Calluna and Chamaenerion to be the principalfoods at this time. Calluna was quite common in Westmoor but it was apparently not being utilised, since more was clipped on the plots outside the exclosures than on those inside. Chamaenerion was not observed in the wood at any time. Although the clipping suggested Pteridium to be the main summer food, casual observation in Westmoor indicated it was not being heavily used.

The Forestry Commission's estimate of deer population size in Westmoor of six deer was similar to that of eight deer by S. Zilberman (pers. comm.). If such a small number of animals were constantly moving into and out of the wood and utilising other feeding sites available in the forest types adjoining Westmoor, then feeding pressure in the wood might be expected to be light, in the growing season. If this view is true, then it was probable that the sampling intensity employed would have been insufficient to reveal which plants were most heavily used. Therefore, the suggestion from the clipping study of Pteridium being the main food is probably incorrect. The variation between weights of individual species inside and outside the exclosures probably result from random variability and in no way indicate the diet of the deer in Westmoor Plantation.

Because the difference in the total weights of vegetation between the exclosed and open plots was so small, these two sets of data may be pooled to provide a quantitative estimate of the food available to the deer at the end of the growing season. Similar work by Bobek et al (1972) in a deciduous forest in Poland indicated that the total dried weight of available vegetation was much greater in summer than in any other season.

If this situation applies in Westmoor also, then the weight of the food available there to the deer in autumn and winter will be much less than that available at the end of the summer.

Furthermore, since the only frequently occurring main food in the wood is Calluna and then only in the rides and plantation habitat types, it is suggested that the wood as a whole did not provide an abundant supply of desirable food for the deer in summer. This is probably because most of Westmoor is covered with unthinned pole stage conifers. A lack of food means few deer, hence the small size of the deer population. It therefore seems that when conducting this type of work, it is best to choose an area with a plentiful food supply and a fairly large deer population.

4.5 Summary

1. Determination of diet was based on three methods; rumen contents and faecal analysis, and comparison of the dried weights of clipped vegetation from exclosed and open plots. Faecal analysis was also used to determine the winter diet of stray sheep.

2. Samples of rumen contents were collected from 83 deer shot throughout the forest from January 1973 through July 1974. These samples were examined using the point frame method of Chamrod and Box (1964). Faeces were collected from the study area during each month of 1973 and 1974. The faecal fragments consisting of plant epidermis and cuticle were examined microscopically and identified to species by reference to collections of mounted preparations and photomicrographs of the epidermises of known plant species.

3. Seasonal changes in diet were strongly influenced by seasonal plant availability and it is suggested that plant quality also caused changes in the diet. Rumen contents analysis indicated a) Calluna to be the most preferred food in the annual diet, b) dwarf shrubs to be the most important

plant group and c) grasses and grasslike plants and Chamaenerion angustifolium to be important foods in spring and summer. Faecal analysis indicated dwarf shrubs to be the most heavily used plant group with Calluna the most important species in each month, and gave higher values for the use of Calluna than did the former method. Both methods indicated similar levels of use of the different herb species, but rumen contents analysis indicated a much greater use of Chamaenerion than did faecal analysis. Grasses present in rumen contents could not be identified to the genus or species level, but the opposite was true for their presence in faeces.

4. It is suggested that faecal analysis indicated a higher level of use of Calluna than did rumen contents analysis because a) Calluna was more available in the study area from where faeces were collected, than in the forest as a whole from where samples of rumen contents were obtained or b) Calluna might be more resistant to digestion than other plants, thus causing faecal analysis to indicate a higher level of use.

It is suggested that rumen contents analysis indicated a greater use of Chamaenerion than did faecal analysis because Chamaenerion is almost completely digested resulting in its under-representation in the faeces.

5. In the clipping study Pteridium aquilinium was the species with the greatest positive difference between exclosed and open plots. Pteridium was shown to be not a main food by comparison with rumen contents and faecal analysis data. There was no evidence of grazing in the open plots, although Pinus sylvestris and Betula growing in the plantation away from the open plots there, were heavily browsed. The inability of the clipping study to show preferred species is attributed to too low a sampling intensity. The similarity between the total weights of vegetation clipped from inside and outside the exclosures is probably due to random variability. However,

the data obtained do provide an indication of the quantity of food available to the deer in summer.

6. Calluna was the most heavily used food by the sheep, although Luzula sp. had the highest preference rating. Grasses and grasslike plants were the main plant group in the sheep diet followed by dwarf shrubs. It is suggested that more work needs to be done over the year as a whole, before the degree of dietary overlap between the sheep and deer can be understood.

5. DETERMINATION OF AGE

5.1 Introduction

Many different methods are used to determine the age of mammals, but not all of these are applicable to individual species (Morris 1972). Methods which can be applied to roe deer are considered here. These include tooth eruption and wear, counts of annual layers in dental cementum, dry weight of the eye lens and body weight.

The sequence of tooth eruption is a reliable indicator of age up to the time when a deer acquires the full set of permanent teeth. The degree of wear of the permanent mandibular teeth has been reported to vary markedly between individuals occupying the same and different habitats (Quimby and Gabb 1957, Robinette, Jones, Rogers and Gashwiler 1957, Sergeant and Pimlott 1959 and Gilbert and Stolt 1970). However, the method is used to estimate the age of roe deer in Denmark (Anderson 1953, Klein and Strandgaard 1972) and in Sweden (Borg 1970). Rieck (1970) tested the wear technique as used in Germany on 250 known age roe deer jaws and found that it accurately estimated the age of 80% of the sample. Szabik (1973) found the method as used in Poland to be much less reliable.

Criteria relating age to the observed degree of molar eruption and wear, on the lines of those described for O. virginianus by Severinghaus (1949) and Ryel, Fay and Van Etten (1961), and for O. hemionus by Robinette et al (1957), have not been established for roe deer in Britain. Nevertheless, the age of roe deer is often estimated by the wear method in Britain also. Prior (1968) even stated it to be the most reliable technique.

Age has been determined from the annual pattern in deposition of dentine (see Morris 1972), but it is more usually determined from that in cementum, which according to Klevezal and Kleinenberg (1966) is the most accurate and nearly universal method of age determination in mammals. The annual layer in the cementum of tooth sections viewed under reflected light consists of two bands: a broad band of opaque cement composed of collagen with a large number of cementocytes and usually calcified, and a narrow band of transparent cement composed of collagen with a small number of cementocytes and strongly calcified (Klevezal and Kleinenberg 1966). Accessory layers similar to the narrow translucent bands are known to occur in some individuals, as rut lines in males (Low and Cowan 1963, Mitchell 1967) or related to lactation in females (Aitken 1975) or as split layers which occur in both sexes, but are unrelated to dietary or hormonal changes during breeding (Lockard 1972).

Many workers who have used counts of cementum layers for determining age in ruminants have found it reliable, for example Sergeant and Pimlott (1959), McEwan (1963), Low and Cowan (1963), Novakowski (1965), Ransom (1966), Gilbert (1966), Mitchell (1967), Riemers and Nordby (1968), McCutcheon (1969), Kneiss (1969), Hemming (1969), Erickson and Seliger (1969), Wolfe (1969), Lockard (1972), Brokx (1972), Spinage (1972), Thomas and Bandy (1973) and Miller (1974). A few, such as Lowe (1967) and Connally, Dudzinski and Longhurst (1969a) have reported the method to be unreliable, or in need of further evaluation, such as Douglas (1970). In the case of roe deer, Prior (1968) reported that the method was unsatisfactory, presumably for a sample examined from Cranborne Chase. However, White (1974) using material from Northumberland and Aitken (1975) using material from Norfolk, both reported the method to be an accurate means of determining age of roe deer.

The value of weights of dried eye lenses as an indicator of age in mammals was first demonstrated by Lord (1959) for Sylvilagus floridanus. The work has since been applied to other mammals by Kolenosky and Miller (1962), Longhurst (1964), Novakowski (1965), Friend (1967), Connally et al (1969a.b.), Fisher and Perry (1970), Anderson and Jensen (1972) and Brokx (1972) with varying degrees of success. Connally et al (1969a.) stated that the method was only useful if precise ages of deer were required up to 12 months of age. Novakowski (1965) and Erickson, Anderson, Medin and Bowden (1969) found the method was of no use for determining age of individuals over two years in Bison bison and in O. hemionus, because of overlap in the weight frequency distribution of successive year classes. The method has not been evaluated for roe deer, although Prior (1968) did mention that it was being investigated.

Body weights have been tested as a means of determining age, in bison by Novakowski (1965), in fallow deer by Chaplin and White (1969) and in roe deer by Aitken (1975), as weight is an easily obtainable measure of growth which might provide an index to age. All of these authors reported the method to be unreliable. However, in the African elephant (Loxodonta africana), where it is not practicable to weigh the whole animal, Laws, Parker and Archer (1967) found that the weight of the hind leg, which was directly proportional to total body weight could be used to estimate age reliably.

The aims of the work reported here were to investigate the reliability of using the above methods to determine the age of roe deer.

5.2 Material and Methods

The following methods commonly employed to determine the age of large mammals were used: Degree of molar eruption and wear. Number of layers in dental cementum of M_1 and I_1. Dried weights of eye lenses. Body weights.

The lower jaws of 101 roe deer were collected from culling operations carried out by the Forestry Commission in Hamsterley Forest between November 1972 and July 1974. Lower jaws were also collected from three deer found dead in this forest during the same period, and from a doe shot by the Forestry Commission at Slaley Forest, Northumberland in December 1973. The latter deer had been ear tagged five years earlier and at the time of marking, its age was estimated at three and a half years using the tooth wear method (G. White pers. comm.). The habitats in Slaley Forest are very similar to those in Hamsterley. In addition, eight lower left jaws were obtained from deer shot between June 1970 and November 1972 in privately owned lowland agricultural woodland areas. Four of these latter jaws came from near Netherwitton, Northumberland and the remaining four from Croxdale near Durham City. The jaws of a known age two year old buck were obtained from Hamsterley in June 1975. Eye lenses were obtained from 56 deer between November 1972 and July 1974 in Hamsterley Forest. Body weights were obtained for 50 deer during the same period and from the same area.

5.2.1 Degree of Molar Eruption and Wear

According to Prior (1968), a roe deer has all its permanent teeth by the age of eight to 12 months. In view of the specific age by which young roe at Hamsterley have acquired their permanent teeth being unknown, it was felt reasonable to assume that these young deer would have a complete permanent dentition at the age of 12 months. Because the birth period at Hamsterley extends from mid May to mid June with only occasional births in July, the mean date of parturition was taken to be June 1st and so all roe at Hamsterley were expected to have their permanent teeth by the 1st of June in the year following their birth.

Prior (1968) also mentioned that few deer survived beyond seven to eight years, but that occasionally one survived ten to 12 years. By this age, the cheek teeth were worn almost to gum level. In addition, the consensus of opinion of Forestry Commission Rangers in the Hamsterley area, was that old deer were almost ten years of age. Therefore, it was assumed as a working hypothesis that the maximum age of a roe deer was ten years and that by this age, the molar teeth and in particular the first molar, were worn to almost gum level.

The open season for bucks was from 1st of May to 30th of August. Most bucks were killed in May but in 1974, some were also shot in June and July. Since the 1st June was the mean birth date, a buck could only be a whole number of years old at the time it was shot.

The open season for does was from 1st November to 28th February. Most females were killed in November, but in 1973 some were shot in January and February and in 1974 in December. With 1st June being the mean birth date, a doe when shot would be a whole number of years old plus between five to nine months. The age of each doe was therefore assumed to be a whole number of years plus six months.

As soon as a deer was shot, its age was estimated to be that which best suited the observed degree of molar eruption and wear, within the range from virtually no wear on the permanent teeth at 12 months to almost complete wear of the molars at ten years, and on the assumption that the rate of wear was more or less uniform during the intervening period. Age estimation employing these same criteria was again carried out in the laboratory, shortly after the jaws were brought in from the forest, but without reference to the ages assigned there. As a second and precise measure of wear, the height above the gum line of each of the two buccal cusps of each of the two lower first molars from each of 104 specimens was measured to the nearest 0.5 mm. using a micrometer (from Severinghaus 1949). Although material from 106 specimens was available, the remains of two of the deer found dead lacked the right lower M_1. Since the lower M_1 was required from both jaws of each specimen, these two specimens were excluded from the data. The tooth wear method was not used on the material from Netherwitton and Croxdale, as the samples from these places were too small for comparisons of molar wear to be made with the sample from Hamsterley.

5.2.2 Number of Layers in Cementum of M_1 and I_1.

These procedures were employed after age estimation based on molar wear and eruption had been completed. They involved examination of gross sections of the cementum of M_1 and I_1 and thin sections also of the latter. Details are as follows:

The lower left jaw of each of the 104 deer was placed in a vice and

M_1 sawn vertically in half using a hacksaw, through the plane of section shown in White (1974), and the cut continued through the jaw bone. The sectioned molar tooth was removed from the bone with pliers. The cut surface of each half was polished on ground glass using aluminium oxide as a paste and the structure of the cementum examined using reflected light under a X30 binocular microscope. The procedure of polishing and examining was repeated until maximum clarity of cemental structure was obtained. Clarity was further intensified by using a mild etching solution of formic acid in alcohol. A similar technique was used on the I_1 of 45 jaws, but with a transverse plane of section employed. It proved difficult to count the layers in the cementum of this tooth because of the small size of the sections. Because of this, polishing of the sections was irregular which caused the cementum to wear away rapidly.

Histological examination of the cementum of I_1 was conducted using the following modification of the method of Jensen and Nielsen (1968). The teeth were decalcified in 5% nitric acid for 48 hours and washed in running water for 24 hours to remove all traces of acid. Sections at 20 microns were cut using a cryostat. It proved possible to place seven sections on one slide and to cut 14 sections from each tooth. Sections were affixed to the slides using albumen glycerol. They were stained in Erhlich's haematoxylin for ten minutes and then washed in distilled water to remove excess stain, followed by immersion in alkaline alcohol, 70% alcohol and two changes of 90% alcohol of five minutes each. The sections were then counterstained in eosin for five seconds, dehydrated in two changes of absolute alcohol for five minutes and cleared in xylene for ten minutes before being mounted in D.P.X. mounting medium.

5.2.3 Dried Weights of Eye Lenses

Lenses were removed from the eyes of deer as soon as possible after the deer were shot and always within 12 hours of death. The lenses were stored in 5% formaldehyde solution for periods of up to three months and then dried in an oven at 80°C to constant weight.

5.2.4 Body Weights

The gralloched body weight was measured to the nearest 0.2 kg. using a torsion balance. Gralloched weight refers to carcass weight minus the oesophagus, trachea, thoracic and abdominal viscera.

5.3 Results

5.3.1 Age from the Degree of Molar Eruption and Wear

The dental formula of each of the jaws of the nine doe kids shot between November and January was pm_1, pm_2, pm_3, M_1, M_2. The jaws of each of the 24 bucks one year old, still retained the deciduous premolars while having the third molar incompletely erupted. Each of the six 18 month old does had the full dentition. A yearling buck which died at the end of August, had the complete permanent dention except for PM_1 and the posterior cusp of M_3 being still incompletely erupted.

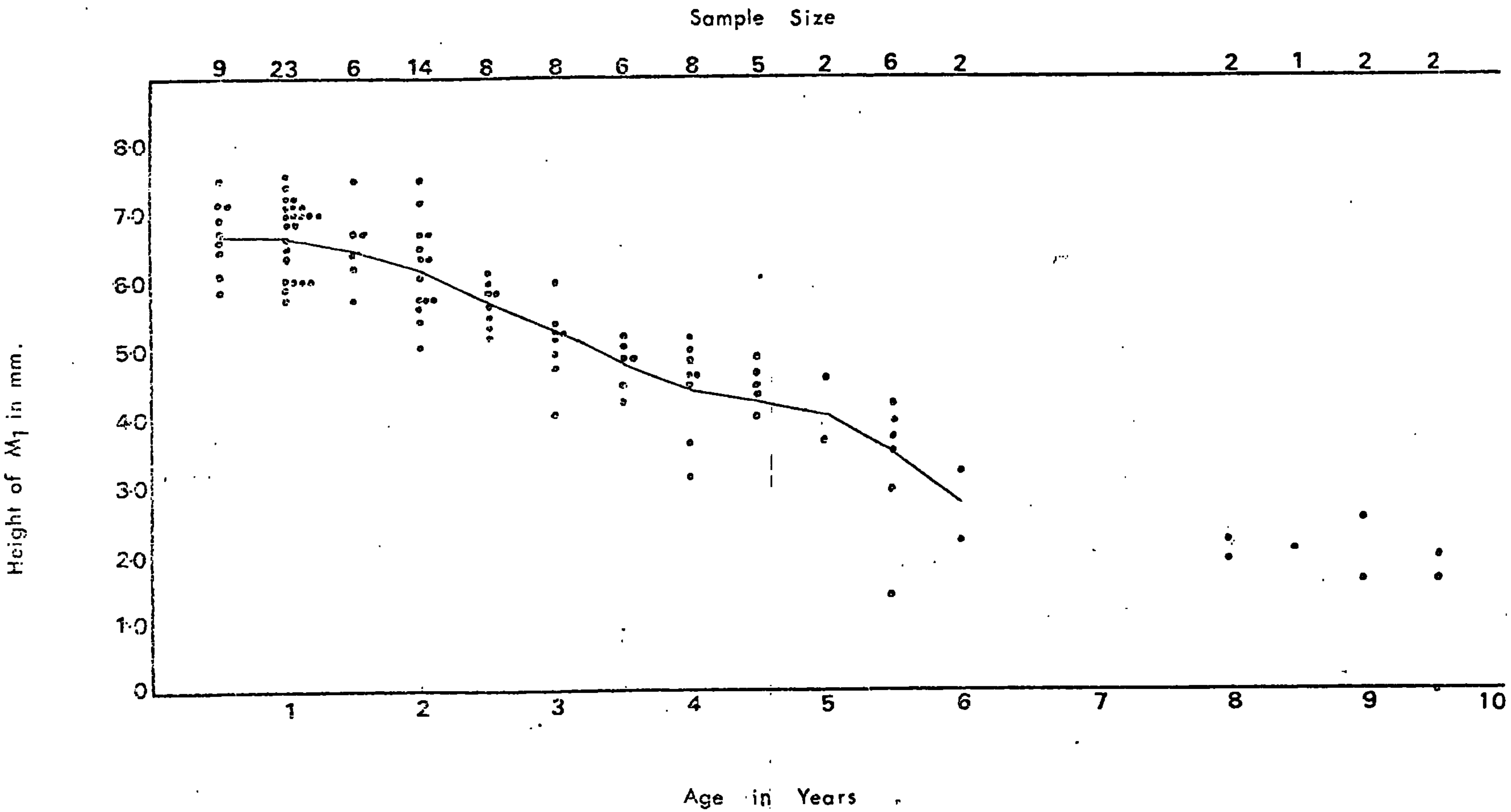
The mean height of the buccal cusp of the first molars decreased steadily with age as indicated by counts of cementum layers (Fig. 16). If accuracy of the age indicated by cementum layer counts can be assumed, these data indicate firstly a uniform mean rate of decrease with age, and secondly, considerable overlap between year classes in mean buccal cusp height. There is no evidence of differences in the rate of wear of M_1 between the sexes.

5.3.2 Layers in the Cementum of M_1 of Deer from Hamsterley Forest

The structure of the cementum usually consisted of layers of broad white cementum, alternating with narrower dark layers, representing summer and winter growth respectively. Since a white layer and a dark layer together constitute one year (White 1974), a count of the number of dark layers provided the age of the deer (see Plates 8 and 9).

In each of the molars examined from nine doe kids shot between November and January, the cementum consisted solely of a broad white band. In the

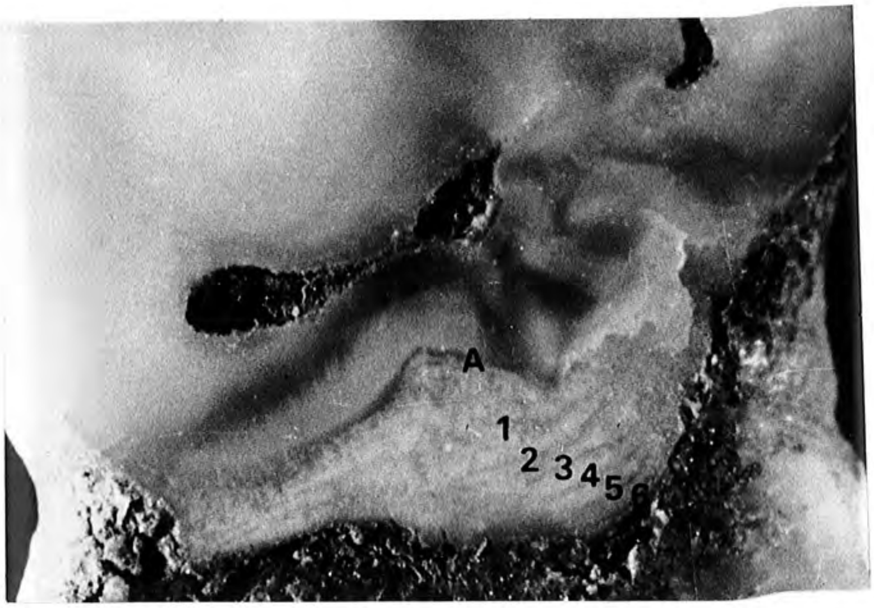
Fig. 16. Mean height of the buccal cusps of the lower M_1 related to age from counts of layers in cementum. The data are based on the jaws collected from Hamsterley and Slaley, except for a 12 month old and a 24 month old deer from the former area. The line is drawn between the mean values of the different age classes.



Sample Size
9 23 6 14 8 8 6 8 5 2 6 2 2 1 2 2
Height of M_1 in mm.
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0
0
1 2 3 4 5 6 7 8 9 10
Age in Years

Plate 8. Section of M_1 showing layers in the cementum of a six year old roe buck (x 30). A is the dentine-cementum interface.

Plate 9. Section of M_1 showing layers in the cementum of a nine and a half year old roe deer (x 100) (A is as Plate 8).


A
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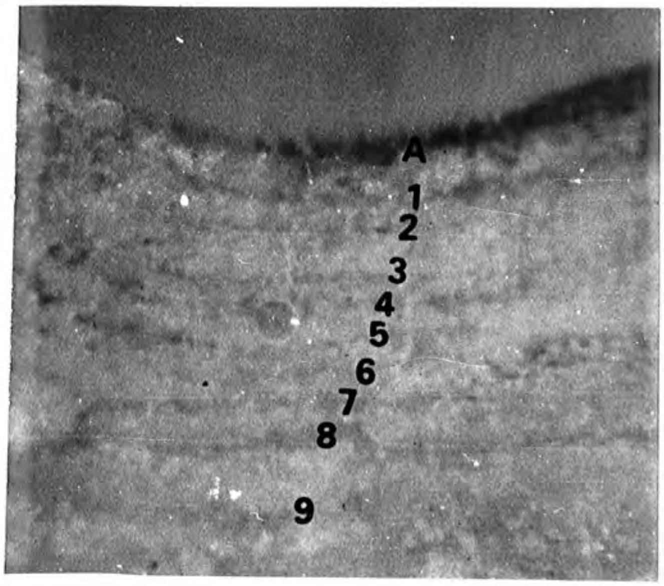
2
3
4
5
6


A
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9

cementum of the molar of each of 17 out of 24 one year old bucks, a dark layer lay between two white layers, whereas the M_1 cementum of each of the other seven bucks consisted solely of a broad white band. The sequence of layers in the M_1 cementum of all six of the 18 month old does, consisted of a dark layer separated by an inner and an outer white layer. In 12 two year old bucks, including the known age Hamsterley deer, alternating white and dark layers were present in the molar cementum, whereas in that of each of three other two year old bucks, the ages of which were determined from counts of layers in the cementum of histological sections of I_1, the cementum consisted solely of a broad white layer. The above information indicates that the dark layer or layers are not clearly visible in the dental cementum of some young roe deer.

Alternating white and dark layers were present in the cementum of M_1 examined from the remaining 52 deer of two and a half years of age and over, including the specimen from Slaley Forest. The outermost zone of cementum in these remaining specimens consisted of a white layer, and the sample was comprised of 24 bucks shot or found dead between May and July and 28 does shot between November and February. A dark layer, corresponding to growth during the winter in which the does were shot, was not seen in the cementum of M_1 of any of the above females.

The age of the marked buck from Hamsterley as determined from counts of cementum layers in M_1, agreed with the known age of two years. Counts of the layers in the cementum of M_1 of the marked Slaley doe indicated it to be nine years old. Since it was shot in Decemeber, it would have been 9.5 years of age. This age is one year older than that expected (see Section 5.2).

5.3.3 Layers in the Cementum of M_1 of Deer from Croxdale and Netherwitton

All specimens over one year of age had alternating white and dark layers present in the M_1 cementum. On the assumption of a mean birth date of 1st June, these deer included a one year old buck, a two year old buck, a two and a half year old doe, a four year old buck and two five year old bucks. The M_1 cementum of a six month old kid doe and a nine month old buck kid consisted solely of a broad white layer.

5.3.4 Layers in the Cementum of I_1 of Deer from Hamsterley Forest

Alternating white and dark layers were present in the cementum of gross sections of I_1. However, it proved extremely difficult to count the number of these layers accurately and so the technique was abandoned.

The cementum of the stained sections of I_1 consisted of broad pink layers and slightly narrower and sometimes wavy blue layers, corresponding to summer and winter growth respectively (see Plates 10 and 11).

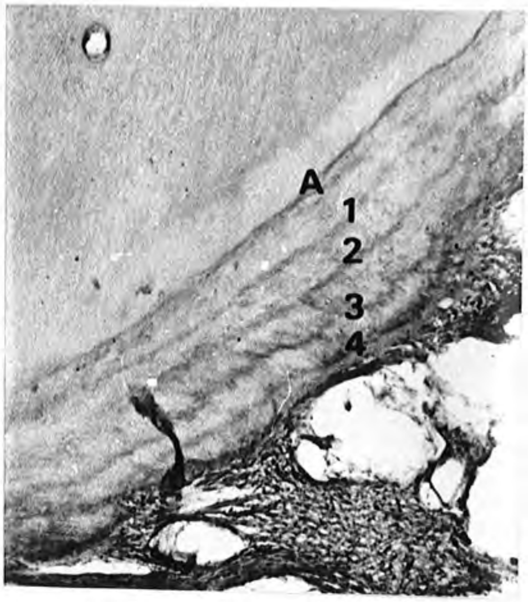
The age as determined using this method, agreed with those determined from the corresponding M_1 in all but five out of 60 deer, where comparisons were possible. As judged by the ages determined from I_1, these five deer consisted of two 12 month old bucks, and three 24 month old bucks. No dark winter layer or layers occurred in the cementum of the corresponding M_1 of these five animals. The age distribution of the sample histologically examined was as follows:

Age Class in Years	Number of Jaws
0.5	2
1	9
1.5	6
2	9
2.5	5
3	4
3.5	3
4	7
4.5	4
5	2
5.5	5
6	2
9	1
9.5	1

A slight indication of the formation of a dark layer in the form of a thin blue line, was found at parts of the outer edge of the cementum of I_1, in three does shot in January, a kid and two adult deer in their

Plate 10. Histological section of I_1 showing layers in the cementum of a four year old buck (x 100). (A is as Plate 8).

Plate 11. Histological section of I_1 showing layers in the cementum of a six year old buck (x 100). (A is as Plate 8)


A
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2
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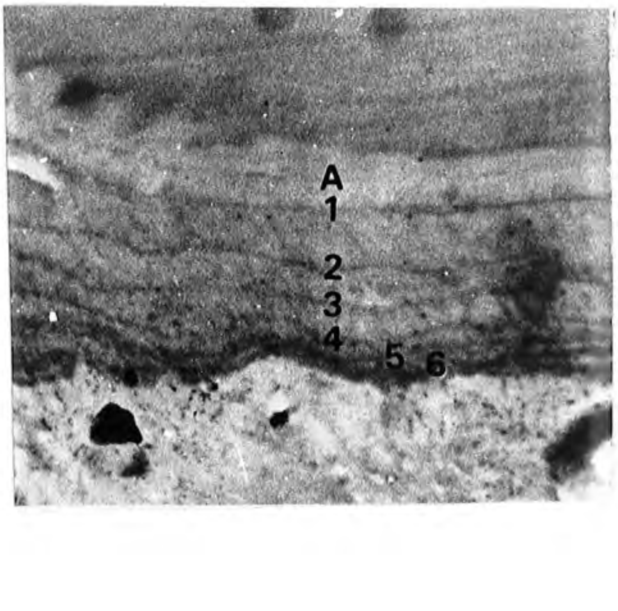

A
1
2
3
4
5 6

second and sixth year respectively, and in three does in their second year, shot in February. This indication of winter layer formation was absent in the cementum of I_1 of two other does each in their sixth year, shot in February.

5.3.5 Layers in the Cementum of I_1 of Deer from Croxdale and Netherwitton

The first incisor was available for only one specimen, shot at Croxdale. This was a five year old buck. The number of layers in the cementum of I_1 agreed with the number in the cementum of M_1.

5.3.6 Comparison of Age as Determined from Counts of Cementum Layers and Molar Wear.

The age assigned to each jaw in the laboratory on the basis of eruption and wear, in all cases was identical with that assigned in the forest. Direct comparisons of these estimates and those determined from counts of cementum layers were therefore possible.

As the age of deer up to 15 months can be accurately determined from molar eruption, age comparisons using the above methods are only given for deer 18 months of age and over. As seen from Table 45, molar wear alone accurately estimated the age of about half of the total sample of 71. Over and underestimates of age by a year were almost equal at about one fifth of the total each. The ages of about one twelfth of the sample were overestimated by two years.

5.3.7 Age from Weights of Eye Lenses

A scatter of mean eye lens weights with age is shown in Fig. 17. This indicates a rapid increase in lens weight up to one year of age, followed by a more gradual increase to about five years. There is extensive overlap between year classes of one year of age and over.

5.3.8 Age from Body Weights

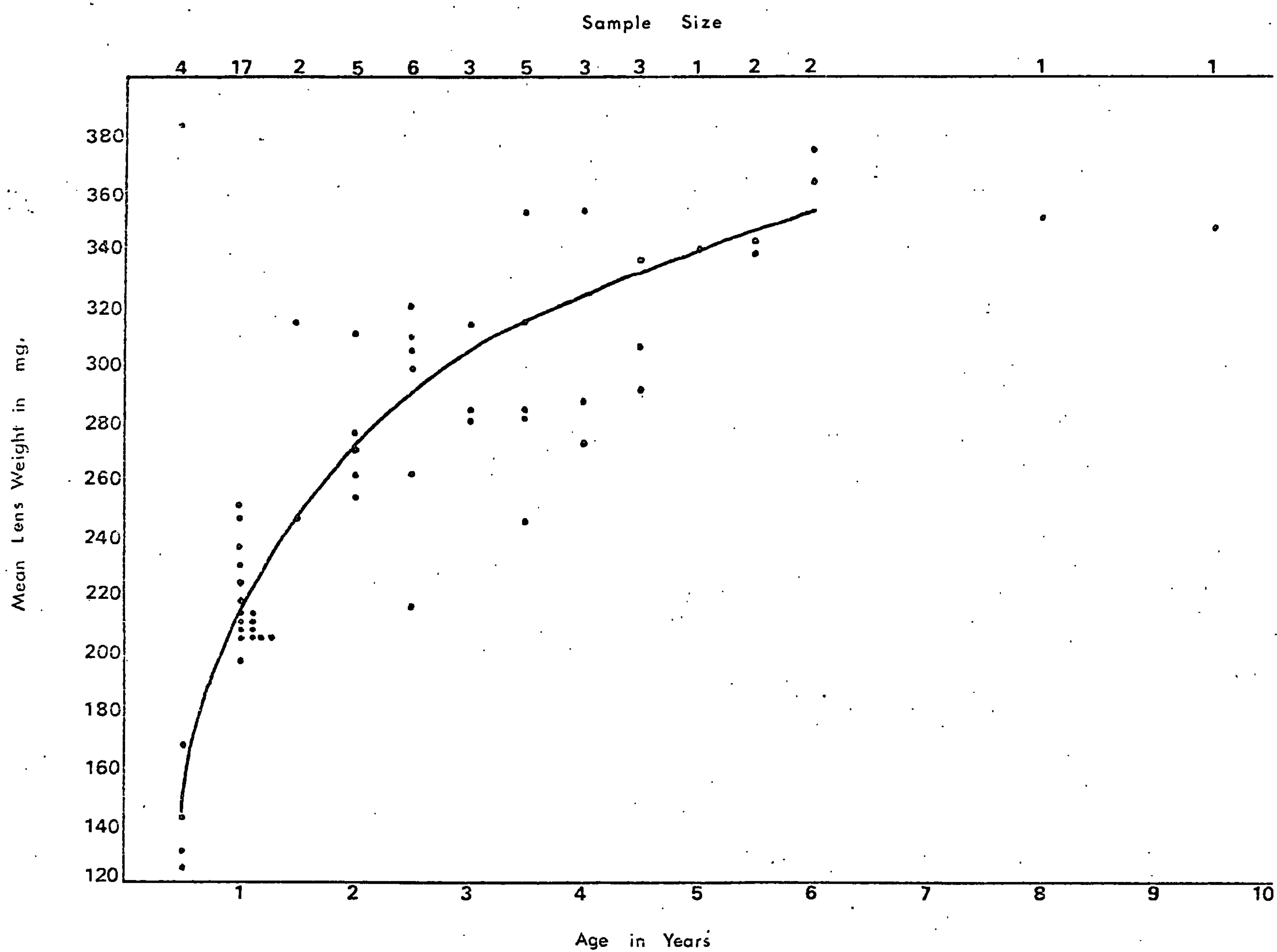
A scatter of the gralloched body weight with age is shown in Fig. 18. This indicates an increase in body weight up to 18 months of age, but

Table 45. Comparison of ages determined from cementum layers with age estimated from molar wear.

Age class from cementum layers[a]	Number of jaws in age class based on number of cementum layers	Number of jaws in age class based on molar wear	Number of jaws the age of which when estimated from tooth wear disagreed by:		
			+ 2 years	+1 year	-1 year
1.5	6	3	0	3	0
2	13	11	0	2	0
2.5	8	2	0	1	5
3	8	1	2	3	2
3.5	6	2	1	1	2
4	8	6	1	0	1
4.5	5	2	1	0	2
5	2	1	1	0	0
5.5	6	2	0	4	0
6	2	1	0	1	0
8	2	2	0	0	0
8.5	1	0	0	1	0
9	2	1	0	0	1
9.5	2	0	0	0	2
Total	71	34	6	16	15

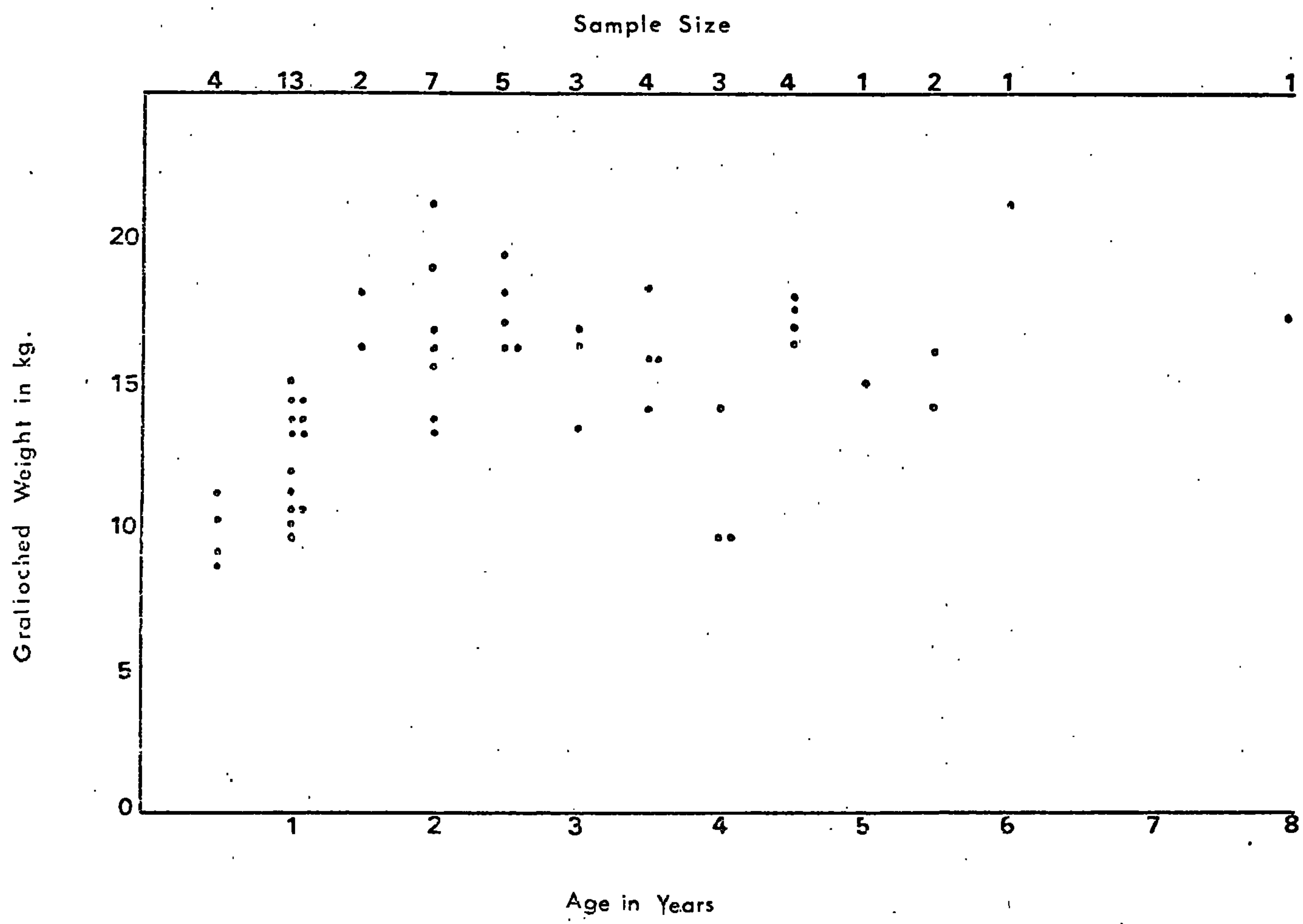
[a] Assuming Counts of cementum layers to be correct. Excludes a two year old deer which was found dead

Fig. 17. Eye lens weights related to age from counts of cementum layers.



Sample Size
4 17 2 5 6 3 5 3 3 1 2 2 1 1
Mean Lens Weight in mg.
380
360
340
320
300
280
260
240
220
200
180
160
140
120
1 2 3 4 5 6 7 8 9 10
Age in Years

Fig. 18. Gralloched body weight in relation to age from cementum layers.


Sample Size
4 13 2 7 5 3 4 3 4 1 2 1 1
Gralloched Weight in kg.
0 5 10 15 20
Age in Years
1 2 3 4 5 6 7 8

none subsequently. There is considerable overlap in weight between all age classes.

5.4 Discussion

It is seen that in roe deer from Hamsterley, like those from Thetford Chase (Aitken 1975), a single broad white and narrow dark layer are formed annually in the dental cementum. In deer from both areas, the white layer is formed between April and December. Aitken (1975) reported that the dark layer was beginning to form in December and it was present in most deer shot in January. In roe from Hamsterley however, the dark layer is apparently formed between January and April. Lockard (1972) found similarly that in O. virginianus the dark layer was laid down during the tenth and eleventh months of the deer's annual cycle.

The apparent absence of a dark layer in the cementum of M_1 of some of the one and two year old deer in fact results from the dark layers formed in the first two winters being difficult to see, while the animal is young, when the gross sectioning technique is used: the absence of layering is thus more apparent than real. This view is supported by the fact that: 1. When the stained sections of the corresponding I_1 of some of these specimens were examined, a dark layer was, or dark layers were present and 2. In the teeth of older specimens, the clarity of the first one or two dark layers was equivalent to that of those laid down in the years immediately preceding death, which suggests that the first dark layers became more distinct with increasing age of the deer. Lockard (1972) found in O. virginianus that layering was more distinct in stained sections than in gross sections of teeth. These results suggest that for young animals, the histological technique would probably be the more reliable method. The wavy layering in some of the sections of I_1 may have been caused by the sectioning procedure and drying of the sections, since layering was more regular in the gross sections of M_1. Brokx (1972) who also used the histological technique, reported the occurrence of constricted irregular layering and of double layers merging into a single one, in cementum of O. v. gymnotis. Neither the lactation zones observed in the cementum of does from Thetford Chase (Aitken 1975) nor the rut lines in that of bucks from Poland (Szabik 1973) and Thetford Chase (Aitken 1975) were found in the dental cementum of either sex at Hamsterley.

Aitken (1975) expressed confidence in the accuracy of the cementum layer technique on the basis of accuracy in the case of known age specimens and of layering in the cementum being distinct in all the specimens from Thetford Chase. White (1974) also considered the dental cementum method to be reliable since distinct white and dark layers were present in the dental cementum of a sample of roe deer teeth which came from different parts of Britain and Europe. Furthermore, the method has provided the correct ages of known age specimens of O. hemionus (Low and Cowan 1963, Thomas and Bandy 1970) from North America, and of Cervus elaphus (Mitchell 1967) from mainland Scotland. In the case of the latter species, however, Lowe (1967) found an inconsistent pattern of layering in the cementum of specimens from the Isle of Rhum, and he stated that the technique was unsatisfactory for determining the age of red deer from this area. At Hamsterley, the finding that the cementum layer method correctly indicated the age of the known age specimen, as being two years, supports the view that age can be determined in roe deer from this area from cementum layers. The age of the Slaley deer was determined to be nine and a half years, compared with the expected age of eight and a half years. The most likely explanation of this discrepancy is that G. White underestimated the age of the Slaley deer by one year at the time it was marked, using the tooth wear method. Because of the clarity of the layering in the material from Netherwitton and Croxdale, the method is likewise considered accurate for age determination of the deer from these localities.

Most workers suggest that the occurrence of layers in the cementum reflects differences in seasonal food quality (Low and Cowan 1963, White 1974, Aitken 1975). It is suggested therefore that at Hamsterley, marked differences exist between summer and winter in the quality of available food. Klevezal and Kleinenberg (1967) suggested that changes in cementum deposition are due to seasonal changes in the intensity of feeding which affects the growth rate of the tissues in cementum, dentine and bone. However, Klevezal and Mina (1973) claimed that in those mammals which do not hibernate, the annual layers in teeth and bones which reflect seasonal growth are mostly determined genetically. These latter authors attributed the variability in the pattern of annual layers in populations of the same species from different geographical areas to the effects of seasonally changing climate acting as a 'stabilising selection pressure'. The meaning of this latter term in Klevezal and Mina (1973) is unclear.

At the outset of the present study, it was assumed that the young roe deer had acquired its permanent teeth by the time it was one year of age. This assumption was later proved incorrect. On the evidence collected, it is concluded that the young roe at Hamsterley is about 15 months old before it has all its permanent teeth. This finding therefore differs from the reports of Prior (1968) and White (1974), whose view was the same as that of Prior and likewise of Aitken (1975), who reported that kids in their first winter, presumably animals seven to eight months of age, have M_3 completely erupted, and by one year have their full permanent dentition. This indicates that the kids in Thetford Chase have acquired M_3, four to six months, and P_1, P_2 and P_3 up to three months earlier than the deer in Hamsterley. Such a lack of uniformity in the pattern of teeth replacement has also been reported to occur in the genus Odocoileus (Severinghaus 1949).

The age estimation of specimens according to the observed degree of molar wear, as used in this study and that of White (1974), was a subjective technique, since the method was not based on exact criteria established from known age animals. Aitken (1975) compared the degree of tooth wear of a sample of jaws with that of other jaws which were arranged on a board, in order of age, and which had been determined using the dental cementum method. The preparation of a jaw board in the present study would probably have increased the accuracy of the wear method, given that by using the jaw board, Aitken (1975) correctly determined the age of two thirds of his sample, whereas the method as applied in the present study was accurate for about half of the sample. A jaw board was not used in the present study because the purpose of using the wear method employed was to assess the accuracy with which it would estimate the age of deer in the field at the time they were shot and also because the method has the speed and simplicity required in a tool of management. The level of accuracy attained using the wear method in the present study and that of White (1974) is substantially greater than that quoted in Szabik (1973) for estimation of the ages of roe in Poland, both by the Polish Hunting Association and by a specialist.

In deer from Thetford Chase, the rate of molar wear was not as great as that in deer from Hamsterley. Aitken (1975) found in deer at Thetford, that the height of the molar cusps was greatest in 12 month old deer, whereas at Hamsterley there was no difference in height of these cusps between six month old does and 12 month old bucks. This suggests that in Hamsterley deer, between six and 12 months of age, the rate of growth of the teeth equals the rate of wear, whereas in Thetford deer, growth of the teeth exceeds the rate of wear. In roe from Hamsterley, the degree of molar wear is more or less uniform; decreasing from a mean M_1 buccal cusp height of 6.7 mm. at 12 months, to 2.5 mm. at six years of age, whereas in specimens from Thetford, the height of the same cusp over the equivalent age span decreases from a mean of 7.0 mm. to a mean of 5.0 mm. The rate of wear of the teeth of Thetford deer slows up in middle age. At six years of age there is perhaps a slight reduction in the rate of wear of the teeth of Hamsterley deer. How definite this reduction is, cannot be ascertained because sample sizes are too small for the older age classes.

This more rapid wear of the teeth of the Hamsterley deer makes estimation of age from heights of buccal cusps more reliable: For example, at Thetford the method attempts to separate six age classes over a range of buccal cusp height of 2.0 mm., whereas at Hamsterley the same number of age classes are spread over a range of 4.0 mm. This indicates a greater degree of overlap in molar cusp height, between the different age classes, of the Thetford deer and therefore suggests a greater chance of assigning an incorrect age.

White (1974) in his estimates of the heights of the buccal cusps of M_1 measured from the jaw bone to the buccal cusp and not from the gum line, as was done for the Hamsterley specimens. This difference in measurement criterion probably explains why the data given in White (1974) are dissimilar to those of the present study in buccal cusp height at a given age. White's data indicate the difference between the mean height of the buccal cusp of M_1 of 12 month old specimens and that of six year old specimens to be 4.0 mm., a value equivalent to the decline between the mean M_1 cusp heights of the Hamsterley deer over the same age range. This may reflect the fact that almost all of White's specimens were obtained from habitats similar to those found at Hamsterley.

The difference in the rate of molar wear of the Hamsterley and Thetford Chase deer is possibly not caused by difference in diet. This is because the diet of the Hamsterley deer is principally browse and browse is presumably the main dietary constituent of the Thetford Chase deer also, and both areas are Forestry Commission forests.[1.] It is possible that the Thetford deer eat less than the Hamsterley deer, since the former live in a

[1.] The diet of the Thetford Chase deer is not described in Aitken (1975). However, Thetford Chase is a conifer forest and browse may therefore be assumed to be the main food.

warmer area. If the Hamsterley deer eat more food in order to maintain body temperature, one would expect their rate of tooth wear to be greater. Genetic factors may also be involved; Aitken (1975) mentioned that the Thetford Chase deer were of German origin. The origin of the Hamsterley deer is unknown, but it is unlikely they are the descendants of imported stock, and according to unpublished work by G. White, it is probable that the deer at Hamsterley originated from survivors of the indigenous stock living in Northumberland.

The dry weight of the eye lens as a method to determine age with accuracy, is applicable to deer of under one year only, since it separates only these animals from all others. The method is unreliable for individuals one year old and over because of its inability to differentiate between age classes. The present study suffers to some extent however, from a lack of data in the age classes of three years and over. The method has no advantages over either the dental cementum or tooth wear techniques. The age determination of kids from the degree of molar eruption is more practical than using lens weights and just as accurate. Laws (1967) used lens dry weights as an indication of the precision of determining the age of the African elephant from the replacement and wear of the mandibular dentition. A similar use of eye lenses in roe deer is unnecessary because of the accuracy of age determination based on cementum layering.

Body weight as a criterion for determining the age of roe deer is totally useless over 12 months of age, as the results indicate no relationship between body weight and age of deer over one year of age. The same conclusion was reached by Aitken (1975).

Both the tooth wear and the tooth measurement method provided results useful for management. There is little difference in the accuracy of these two methods, since both lead to similar levels of over and underestimation of age. The wear method as used in the field, will accurately estimate the age of deer up to 15 months and accurately estimate also the age of about half the deer in the older age classes. Over or underestimation of age by one year when spread over a large sample is unlikely to have much effect on estimating the age structure of the sample. Whenever layering is absent in the dental cementum of roe (see Prior 1968), the wear method is the only technique to use, but its use requires knowledge of the age span of the deer in the locality concerned if it is to provide more than an index of age. However, if layering does occur in the cementum, then the dental cementum technique can be used to give a precise determination of age, if required. Because the differences in the accuracy between the gross sectioning and histological techniques is so small, the sectioning of M_1 is preferred because of its greater simplicity and rapidity.

5.5 Summary

1. Age determination of roe deer was based on the degree of molar eruption and wear, layers in the cementum of M_1 and I_1, dried weights of eye lenses and body weights.

2. A total of 105 jaws were examined from Hamsterley Forest, one of which was of known age, and one jaw the age of which was known to be at least five years and probably 8.5 years was obtained from Slaley Forest. Four jaws were obtained from Croxdale and four from Netherwitton.

3. The age at which the Hamsterley deer had acquired all their permanent teeth was estimated to be 15 months. Age estimation in the field based on a subjective assessment of molar eruption and wear proved accurate for about half of all deer, the ages of which were estimated by this method. There was no evidence of differences in the rate of wear of M_1 between the sexes. Methods of age estimation based on eruption and wear are practical, but not highly reliable.

4. Alternating white and dark layers were present in the cementum of nearly all of the first molars examined. Exceptions to this were some one year and two year old bucks. The cementum of M_1 of these deer consisted of a single white band. Layering was clearly visible in the histological

sections of I_1 of all specimens examined, including the above exceptions. Layers were also present in the cementum of M_1 of most of the specimens examined from Croxdale and Netherwitton, exceptions being a six month old doe and a nine month old buck. The cementum of M_1 of these deer consisted of a broad white band. The I_1 of these two specimens was unavailable for histological examination. The dental cementum method is considered the most accurate for determining the age of deer.

5. Weights of eye lenses showed a rapid increase up to one year of age followed by a more gradual increase to about five years. Use of this method for determination of age is not recommended.

6. Body weight increased up to 18 months of age but not subsequently. This method is therefore also unsuitable in general for the determination of age.

6. GENERAL DISCUSSION

The roe is principally a forest dweller in Britain, although it does inhabit farmland and open upland areas. The present study has indicated that the distribution of roe deer in a large area of forest is not much influenced by the distribution of canopy cover, although this cover type may determine habitat use locally. Ground cover, in contrast, is important in influencing deer distribution.

It is axiomatic that food is of absolute importance. The present study has shown that roe distribution is significantly correlated with the density of *Calluna*, *Picea* and of grasses and grasslike plants. These correlations should not be taken as suggesting that deer distribution is associated with these plant types because they are used as foods. In fact, grasses and grasslike plants are only a minor food: it is probable that they provide bedding sites which could perhaps be the real cause of their correlation with the indices of deer distribution. *Picea* is also unimportant as a food, but it does provide a fraying stock for the roe buck, particularly the very young trees, although the branches of plantation and pole stage trees are also frayed.[1] Although browsing did occur on cultivated trees in the forest, it was not a serious problem. This is perhaps because there are adequate supplies of *Calluna* which is the main alternative browse and the most preferred food, and because population density is maintained at a low level by the Forestry Commission culling programme. Juon (1963) reported that in parts of Europe, browsing damage to silvicultural areas was reduced by the presence of non-commercial tree and shrub species as alternative food sources.

At Hamsterley, sites with *Calluna* and other dwarf shrubs should be maintained for deer. In addition, herbs and grasses and grasslike plants

[1] Methods leading to possible reductions in fraying damage are discussed in Bramley (1972) and Cumming (1974).

growing along the edge of the forest roads, should not be mowed during the late spring and summer, which is the current practice, since the plants in these areas of edge provide food which is utilised by the deer at these times. However, mowing of these areas in September or later would probably enhance the growth of this edge vegetation in the following spring.

The utilisation by deer of the ground flora of a forest leads to the conversion of solar energy into a product of economic importance. If the deer are mostly utilising dwarf browse, then the gramineous proportion of the vegetation could be utilised by sheep. It would be best if possible, to restrict the sheep to plantations and areas of edge where grasses and grasslike plants are most abundant and where possible browsing damage to newly planted conifers would be totally insignificant. Although the data presented in this study suggested a degree of dietary overlap in winter, between the deer and sheep, I doubt if this overlap is likely to be of much practical significance on an annual basis. A grazing regime based on both sheep and deer would probably lead to a greater financial return for the forest economy and is a subject worthy of further investigation (see Adams 1975).

In the present study, I have not investigated food quality, a subject completely neglected in research on roe deer in Britain. Although deer can synthesise some of their requirements from basic items through the micro-organisms in the digestive tract (Lockie 1967), many essential chemical constituents are still absent and can only be obtained from a nutritious diet. Such a diet is essential if a population is to be productive and healthy (Klein 1970). Such studies could be devised to answer the following questions (from Dietz 1965).

1. Which areas are of high nutritive quality and which are not?
2. What improvements are required to enhance nutritional needs on different areas?
3. Which plants are most nutritious in each area?

The possible influences of food quality as well as food abundance, cover, population density and social factors on territory and home range size have been discussed in Section 3.4. Cowan (1974), when he discussed the management implications of the behaviour of African bovids, mentioned that the male territories 'because their special requirements are likely to be more precise than those of the herd range, are likely to be limiting in the management sense'. In the case of territorial roe bucks, these special requirements may possibly be a supply of adequate fraying stocks for mock fighting, and for anointing with glandular secretions, and areas of good visibility from where intruding bucks can be observed. In a given area, if the special requirements can be determined and made optimal, then theoretically territory size might be reduced and population density increased.

Study is also required on a method or methods to estimate population size. It is impossible to census a population reliably in a given forest when the method used is observation of the number of territorial bucks, does and non-territorial males in all or part of that forest. This is because observation is too restricted by cover and many deer are never observed. As the present study has shown, even determination of habitat preferences based on observation alone is not completely reliable. It would therefore be worthwhile to investigate the reliability of the pellet group method (see Neff 1968) as a census technique. Firstly however, a daily defecation rate would have to be estimated using captive animals fed on forest forage, and kept in an enclosure. Secondly, a test of the method should be conducted on a population of known size. It would be necessary also to evaluate the technique with regards to sampling intensity, manpower and time required to carry out a pellet group count, before employing the method in a forest with an area of several thousand hectares.

The applicability of the dental cementum technique for determining the age of roe deer should be further investigated by assessing its reliability for determining the age of deer from other areas. Estimation of age in the field, based on molar eruption and wear, has been shown to be fairly reliable. The degree of reliability could be increased by determining the ages of specimens from cementum layers and then preparing a jaw board. These boards could be prepared for or by the forest owners and kept by them at each of their forests. When a deer is shot from a given area, the age of the deer could be rapidly and reliably estimated by reference to the jaw board.

Reliability in determining age is necessary firstly, if comparison of the growth rates of deer from different areas is to be carried out and secondly, if it is of interest to investigate changes in the age structure over a period of years, of a population in a given area. One problem with this latter type of work is that it cannot be assumed automatically that deer shot during culling operations represent a random sample, because management policy may be directed towards reducing fraying damage by shooting yearling bucks, and to reduce population size by shooting adult and yearling does (Bramley 1972). However, it is often a time consuming process waiting for an animal of the required age class to appear before shooting it. Hence, in those forests where large numbers of deer are shot, it is probable that many are shot as a first come basis; this being the case, these animals could be considered as being killed at random, given equal activity of bucks and does and of the different age classes.

LITERATURE CITED

Adams, S. N. 1975. Sheep and cattle grazing in forests. J. Appl. Ecol. 12: 143-153.

Aitken, R. J. 1974. Delayed implantation in the roe deer, Capreolus capreolus. Ph.D. Thesis. University of Cambridge.

Aitken, R. J. 1975. Cementum layers and tooth wear as criteria for ageing roe deer (Capreolus capreolus). J. Zool., Lond. 175: 15-28.

Aldous, S. E. 1944. A deer browse survey method. J. Mammal. 25: 130-136.

Allen, E. O. 1968. Range use, foods, condition and productivity of white-tailed deer in Montana. J. Wildl. Manage. 32: 130-142.

Andersen, J. 1953. Analysis of a Danish roe deer population. Danish Rev. Game Biol. 2: 127-155.

Andersen, J. and Jensen, B. 1972. The weight of the eye lens in the European hare of known age. Acta. theriol. 17:87-92.

Andersen, A. E., Medin, D. E. and Bowden, D. C. 1972. Mule deer numbers and shrub yield utilisation on winter range. J. Wildl. Manage. 36: 571-578.

Andersen, A. E. Medin, D. E. and Bowden, D. C. 1972. Mule deer faecal group counts related to site factors on winter range. J. Range. Manage. 25: 66-69.

Anthony, R. G. and Smith, N. S. 1974. Comparison of rumen and faecal analysis to describe deer diets. J. Wildl. Manage. 38: 535-540.

Batchelor, C. L. 1960. A study of the relations between roe, red and fallow deer, with special reference to Drummond Hill Forest, Scotland. J. Anim. Ecol. 29: 375-384.

Bayless, S. R. 1969. Winter food habits, range use and home range of antelope in Montana. J. Wildl. Manage. 33: 538-552.

Bedell, T. E. 1971. Nutritive value of forage and diets of sheep and cattle from Oregon subclover-grass mixtures. J. Range. Manage. 24: 125-133.

Bergerud, A. T. and Russel, L. 1964. Evaluation of rumen food analysis for Newfoundland caribou. J. Wildl. Manage. 28: 809-815.

Bobek, B. Weiner, J. and Zielinski, J. 1972. Food supply and its consumption by deer in a deciduous forest of southern Poland. Acta theriol. 17: 187-202.

Borg, K. 1970. On mortality and reproduction of roe deer in Sweden during the period 1948-1969. Viltrevy. 7: 121-149.

Bowden, D. C. Anderson, A. E. and Medin, D. E. 1969. Frequency distributions of mule deer faecal group counts. J. Wildl. Manage. 33: 895-906.

Bramley, P. S. 1970. Territoriality and reproductive behaviour of roe deer. J. Reprod. Fert. Suppl. 11: 43-70.

Bramley, P. S. 1972. Management of roe deer (<u>Capreolus capreolus</u>) in small deciduous woodlands. Deer. 3: 144-149.

Bridges, R. J. 1967. Individual white-tailed deer movement and related behaviour during the winter and spring in northwest Florida. M.Sc. Thesis. University of Georgia. Athens.

Brokx, P. A. 1972. Age determination of Venezuelan white-tailed deer. J. Wildl. Manage. 36: 1060-1067.

Brown, J. L. 1964. The evolution of diversity in avian territorial systems. Wilson Bull. 76: 160-169.

Carne, P. H., (Ed). 1974. Deer distribution survey 1967-1972. Deer 3: 279-283.

Chamrod, A. D. and Box, T. W. 1964. A point frame for sampling rumen contents. J. Wildl. Manage. 28: 473-477.

Chamrod, A. D. and Box, T. W. 1968. Food habits of white-tailed deer in south Texas. J. Wildl. Manage. 21: 158-164.

Chaplin, R. E. and White, R. W. G. 1969. The use of tooth eruption and wear, body weight and antler characteristics in the age estimation of male wild and park fallow deer (<u>Dama dama</u>). J. Zool., Lond. 157: 125-132.

Colquhoun, I. R. 1971. The grazing ecology of red deer and blackface sheep in Perthshire, Scotland. Ph.D. Thesis. University of Edinburgh.

Connolly, G. E., Dudzinski, M. L. and Longhurst, W. M. 1969a. The eye lens as an indicator of age in the black-tailed jackrabbit. J. Wildl. Manage. 33: 159-164.

Connolly, G. E., Dudzinski, M. L. and Longhurst, W. M. 1969b. An improved age-lens weight regression for black-tailed deer. J. Wildl. Manage. 33: 701-704.

Cowan, I. McT. 1974. Management implications of behaviour in the large herbivorous mammals. In Geist, V. and Walther, F. (Eds). The Behaviour of Ungulates and its Relation to Management. pp. 921-935. I.U.C.N. 24.

Cumming, H. G. 1966. Behaviour and dispersion in roe deer. Ph.D. Thesis. University of Aberdeen.

Cumming, H. G. 1974. Fraying behaviour and management of roe deer. In Geist, V. and Walther, F. (Eds). The Behaviour of Ungulates and its Relation to Management. pp. 813-830. I.U.C.N. 24.

Dasmann, W. 1971. If deer are to survive. The Wildlife Management Institute. Stackpole Books. Harrisburg.

DeVos, A. and Mosby, H. A. 1969. Habitat analysis and evaluation. In Giles, R. H. (Ed). Wildlife Management Techniques. The Wildlife Society. Washington.

Dietz, D. R. 1965. Deer nutrition research in range management. Trans. N. Am. Wildl. Nat. Res. Conf. 30: 274-285.

Dirschl, H. J. 1963. Food habits of the pronghorn in Saskatchewan. J. Wildl. Manage. 27: 81-93.

Douglas, M. J. W. 1970. Dental cement layers as criteria of age of deer in New Zealand with emphasis on red deer, <u>Cervus elaphus</u>. N.Z.J. Sci. 13: 352-358.

Dzieciolowski, R. 1969a. Winter biomass of browse for herbivorous animals in forest habitats. Ekol. pol. A. 17: 361-372.

Dzieciolowski, R. 1969b. Repartition of habitat niches within the area of red deer (<u>Cervus elaphus</u>) population. Ekol. pol. A. 17: 381-389.

Erickson, J. A. and Seliger, W. G. 1969. Efficient sectioning of incisors for estimating ages of mule deer. J. Wildl. Manage. 33: 384-388.

Erickson, J. A. Anderson, A. E. Medin, D. E. and Bowden, D. C. 1970. Estimating ages of mule deer - an evaluation of technique accuracy. J. Wildl. Manage. 34: 523-531.

Estes, R. D. 1974. Social behaviour of the African Bovidae. In Geist, V. and Walther, F. (Eds). The Behaviour of Ungulates and its Relation to Management. pp. 166-206. I.U.C.N. 24.

Fisher, E. W. and Perry, A. E. 1970. Estimating ages of gray squirrels by lens-weights. J. Wildl. Manage. 34: 825-828.

Franklin, W. L. 1974. The social behaviour of the vicuna. In Geist, V. and Walther, F. (Eds). The Behaviour of Ungulates and its Relation to Management. pp. 477-488. I.U.C.N. 24.

Friend, M. 1967. A review of research concerning eye-lens weight as a criterion of age in animals. N.Y. Fish and Game J. 14: 152-165.

Gardarsson, A. and Moss, R. 1970. Selection of food by Icelandic ptarmigan in relation to its availability and nutritive quality. In Watson, A. (Ed). Animal Populations in Relation to their Food Resources. pp. 47-73. Symp. Brit. Ecol. Soc. 10.

Gibson, W. N. and MacArthur, K. 1965. Roe deer and methods of control in the forests of south Scotland. Forestry. 38: 173-182.

Gilbert, F. F. 1966. Ageing white-tailed deer by annuli in the cementum of the first incisor. J. Wildl. Manage. 30: 200-202.

Gilbert, F. F. and Stolt, L. 1970. Variability in ageing Maine white-tailed deer by tooth wear characteristics. J. Wildl. Manage. 34: 532-535.

Grout, A. J. 1947. Mosses with a hand lens. Intelligencer. Pennsylvania.

Hansen, R. M. Peden, D. G. and Rice, R. W. 1973. Discerned fragments in faeces indicates diet overlap. J. Range. Manage. 26: 103-105.

Hemming, J. E. 1969. Cemental deposition, tooth succession and horn development as criteria of age in dall sheep. J. Wildl. Manage. 33: 552-558.

Henry, B. A. M. 1972. The ecology of the white-tailed deer in Point Pelee National Park, Ontario. M.Sc. Thesis. University of Western Ontario.

Henry, B. A. M. 1975. Habitat use and home range of white-tailed deer in Point Pelee National Park, Ontario. Can. Field-Nat. 89: 179-181.

Holloway, C. W. 1967. The effect of red deer and other animals on naturally regenerating Scots pine. Ph.D. Thesis. University of Aberdeen.

Holsworth, W. N. 1967. Population dynamics of the quokka, Setonix brachyurus, on the west end of Rottnest Island, Western Australia. Aust. J. Zool. 15: 29-46.

Hosey, G. R. 1974. The food and feeding ecology of the roe deer (Capreolus capreolus). Ph.D. Thesis. University of Manchester.

Hyde, H. A. and Wade, A. E. 1962. Welsh Ferns. National Museum of Wales, Cardiff.

Jackson, J. E. 1974. The feeding ecology of the fallow deer (Dama dama L.) in the New Forest. Ph.D. Thesis. University of Southampton.

Jenkins, D., Watson, A. and Miller, G. R. 1963. Population studies on red grouse Lagopus lagopus scoticus (Lath.) in northeast Scotland. J. Anim. Ecol. 32: 317-376.

Jensen, B. and Nielsen, L. B. 1968. Age determination in the red fox (Vulpes vulpes L.) from canine tooth sections. Danish Rev. Game Biol. 5: 1-16.

Julander, O. 1966. How mule deer use mountain rangeland. Utah Acad. Sci. Arts and Letters. 43: 22-28.

Juon, P. 1963. Recent information regarding roe deer nutrition. Schweiz. Ztschr. fuer Forst. 114: 98-117.

Keiss, R. E. 1969. Comparison of eruption-wear patterns and cementum annuli as age criteria in elk. J. Wildl. Manage. 33: 175-180.

Kitchen, D. W. 1974. Social behaviour and ecology of the pronghorn. Wildl. Mongr. 38: 1-96.

Klein, D. R. and Strandgaard, H. 1972. Factors affecting growth and body size of roe deer. J. Wildl. Manage. 36: 64-79.

Klein, D. R. 1970. Food selection by North American deer and their response to over utilisation of preferred plant species. In Watson, A. (Ed.). Animal Populations in Relation to their Food Resources. pp. 25-46. Symp. Brit. Ecol. Soc. 10.

Klevezal, G. A. and Kleinenberg, S. E. 1967. Age determination of mammals from annual layers in teeth and bones. Izd. Nauka. Moskva. 1-142. In Russian: Translation by Israel Program for Scientific Translations Jerusalem 1969.

Klevezal, G. A. and Mina, M. V. 1973. Factors determining the pattern of annual layers in dental tissue and bones of mammals. Zh. Obschch. Biol. 34: 594-605. (Read in English Summary).

Kolenosky, G. B. and Miller, R. S. 1962. Growth of the lens of the pronghorn antelope. J. Wildl. Manage. 26: 112-113.

Krebs, J. R. 1970. Territory and breeding density in the great tit Parus major L. Ecology. 52: 2-22.

Laws, R. M. 1967. Eye lens weight and age in African elephants. East Afr. Wildl. J. 5: 46-53.

Laws, R. M. Parker, I. S. S. and Archer, A. L. 1967. Estimating live weights of elephants from hind leg weights. East Afr. Wildl. J. 5: 106-111.

Leckenby, D. A. 1968. Influences of plant communities on wintering mule deer. Proc. Annual Conf. Western Assoc. State Game and Fish Commissioners. 49: 201-208.

Leuthold, W. 1974. Observations on home range and social organisation of lesser kudu. Tragelaphus imberalis. In Geist, V. and Walther, F. (Eds) The Behaviour of Ungulates and its Relation to Management. pp. 206-235. I.U.C.N. 24.

Linley, M. A. 1973. Food selection of the roe deer (Capreolus capreolus L.) Unpublished Report. Department of Zoology. University of Durham.

Lockard, G. R. 1972. Further studies of dental annuli for ageing white-tailed deer. J. Wildl. Manage. 36: 46-55.

Lockie, J. D. 1967. Deer and their habitat. Forestry. Supplement. 22-27.

Longhurst, W. M. 1964. Evaluation of the eye lens technique for ageing Columbian black-tailed deer. J. Wildl. Manage. 28: 773-784.

Longhurst, W. M. Oh, H. K. Jones, M. B. and Kepner, R. E. 1968. A basis for the palatability of deer forage plants. Trans. N. Am. Wildl. Nat. Res. Conf. 33: 181-192.

Lord, R. D. 1959. The lens as an indicator of age in cottontail rabbits. J. Wildl. Manage. 23: 358-360.

Loveless, C. M. 1967. Ecological characteristics of a mule deer range. Colorado Game Fish and Parks Dept. Tech. Pub. No. 20. 1-124.

Low, W. A. and Cowan, I. McT. 1963. Age determination of deer by annular structure of dental cementum. J. Wildl. Manage. 27: 466-471.

Lowe, V. P. W. 1967. Teeth as indicators of age with special reference to red deer (Cervus elaphus) of known age on Rhum. J. Zool., Lond. 152: 137-153.

Lowe, V. P. W. and Donally, R. J. 1973. A prescription for roe deer management and conservation. Quart. J. Forestry. 67: 343-350.

Marchinton, R. L. and Jeter, L. K. 1966. Telemetric study of deer movement ecology in the southeast. Proc. Annual Conf. Southeastern Assoc. Game and Fish Commissioners 20: 189-206.

Marshall, A. D. and Whittington, R. W. 1968. A telemetric study of deer home ranges and behaviour of deer during managed hunts. Proc. Annual Conf. Southeastern Assoc. Game and Fish Commissioners. 22: 30-46.

Martin, W. K. 1969. The concise British flora in colour. Eburg. London.

McCaffery, K. R. and Creed, W. A. 1966. Significance of forest openings to deer in northern Wisconsin. Wisconsin Dept. Nat. Res. Tech. Bull. 44.

McConnell, B. R. and Smith, J. G. 1970. Frequency distributions of deer and elk pellet groups. J. Wildl. Manage. 34: 29-36.

McCutcheon, M. 1969. Age determination of pronghorns by the incisor cementum. J. Wildl. Manage. 33: 172-175.

McDougall, P. 1972. The feral goats of Kielderhead Moor. M.Sc. Dissertation. University of Durham.

McDougall, P. 1975. The feral goats of Kielderhead Moor. J. Zool., Lond. 176: 215-246.

McEwan, E. H. 1963. Seasonal annuli in the cementum of the teeth of the barren ground caribou. Can. J. Zool. 41: 111-113.

McMahon, C. A. and Inglis, J. M. 1974. Use of Rio Grande plains brush types by white-tailed deer. J. Range. Manage. 27: 369-374.

McNab, B. K. 1963. Bioenergetics and the determination of home range size. Am. Nat. 97: 113-140.

Michael, E. D. 1970. Activity patterns of white-tailed deer in south Texas. Texas J. Sci. 21: 417-428.

Miller, F. L. 1968. Observed use of forage and plant communities by black-tailed deer. J. Wildl. Manage. 32: 142-149.

Miller, F. L. 1970. Distribution patterns of black-tailed deer (Odocoileus hemionus columbianus) in relation to environment. J. Mammal. 51: 248-260.

Miller, F. L. 1974. Age determination of caribou by annulations in dental cementum. J. Wildl. Manage. 38: 47-53.

Miller, G. R. 1971. Grazing and the regeneration of shrubs and trees. In: Range Ecology Research, First Progress Report. pp. 27-40. The Nature Conservancy, Edinburgh.

Mishra, R. H. 1971. Habitat requirements of roe deer. M.Sc. Thesis. University of Edinburgh.

Mitchell, B. 1967. Growth layers in dental cementum for determing the age of red deer (Cervus elaphus L.) J. Anim. Ecol. 36: 279-293.

Montgomery, G. G. 1963. Nocturnal movements and activity rhythms of white-tailed deer. J. Wildl. Manage. 27: 422-428.

Morris, P. 1972. A review of mammalian age determination methods. Mammal Rev. 2: 69-103.

Moss, R. and Parkinson, J. A. 1972. The digestion of heather (Calluna vulgaris) by red grouse (Lagopus lagopus scoticus). Br. J. Nutr. 27: 285-298.

Mukinya, J. J. 1973. Density, distribution, population structure and social organisation of the black rhinoceros in Masai Mara Game Reserve. E. Afr. Wildl. J. 11: 385-400.

Neal, B. R., Pulkinen, D. A. and Owen, B. D. 1973. A comparison of faecal and stomach contents analysis in the meadow vole (Microtus pennsylvanicus) Can. J. Zool. 51: 715-721.

Neff, D. J. 1968. The pellet group count technique for big game trend, census and distribution: A review. J. Wildl. Manage. 32: 597-613.

Nixon, C. M. McClain, M. W. and Russel, K. R. 1970. Deer food habits and range characteristics in Ohio. J. Wildl. Manage. 34: 870-887.

Novakowski, N. S. 1965. Cemental deposition as an age criterion in bison and the relation of incisor wear, eye-lens weight and dressed bison carcass weight to age. Can. J. Zool. 43: 173-178.

Ozoga, J. J. 1968. Variations in microclimate in a conifer swamp deeryard in northern Michigan. J. Wildl. Manage. 32: 574-585.

Parker, R. E. 1973. Introductory statistics for biology. Institute of Biology. Edward Arnold. London.

Prior, R. 1968. The roe deer of Cranborne Chase. Oxford University Press. London.

Prior, R. 1973. Roe deer: management and stalking. The Game Conservancy Booklet No. 17.

Quimby, D. C. and Gabb, J. E. 1957. Mandibular dentition as an age indicator in Rocky Mountain elk. J. Wildl. Manage. 21: 435-451.

Ransom, A. B. 1967. Reproductive biology of white-tailed deer in Montana. J. Wildl. Manage. 31: 114-124.

Rawes, M. 1974. Moor House 15th annual progress report. The Nature Conservancy Council. Grange-over-Sands.

Reimers, E. and Nordby, O. 1968. Relationship between age and tooth cementum layers in Norwegian reindeer. J. Wildl. Manage. 32: 957-961.

Rieck, W. 1970. Alter und gebissabnutzung beim rehwild. Zeit. fuer Jagdwiss. 16: 1-7. (Read in English Translation).

Riney, T. 1957. The use of faeces counts in studies of several free ranging mammals in New Zealand. N.Z. J. Sci. Technol. B.38: 507-532.

Robel, R. J. and Watt, P. G. 1970. Comparison of volumetric and point-analysis to describe deer food habits. J. Wildl. Manage. 34:210-213.

Robertson, I. J. M. 1967. The ecology and management of deer in temperate forests. M.Sc. Thesis. University of Edinburgh.

Robinette, W. L. Jones, D. A. Rogers, G. and Gashwiler, J. S. 1957. Notes on tooth development and wear from Rocky Mountain mule deer. J. Wildl. Manage. 21: 134-153.

Rohlf, F. J. and Sokal, R. R. 1969. Statistical tables. Freeman. San Francisco.

Ryel, L. A. Fay, L. D. and Van Etten, R. C. 1961. Validity of age determination in Michigan deer. Papers Mich. Acad. Sci. Arts and Letters. 46: 289-316.

Sergeant, D. E. and Pimlott, D. H. 1959. Age determination in moose from sectioned incisor teeth. J. Wildl. Manage. 23: 315-321.

Severinghaus, C. W. 1949. Tooth development and wear as criteria of age in white-tailed deer. J. Wildl. Manage. 13: 195-216.

Short, R. V. and Hay, M. F. 1965. Delayed implantation in the roe deer (Capreolus capreolus). Symp. Zool., Lond. 15: 173-193.

Siuda, A., Zurowski, W. and Siuda, H. 1969. The food of the roe deer. Acta theriol. 14: 247-262.

Smith, C. C. 1968. The adaptive nature of social organisation in the genus of tree squirrels, Tamiascium. Ecol.Monog. 38: 31-63.

Snedecor, G. W. and Cochran, W. G. 1967. Statistical methods. Iowa State University Press. Iowa.

Sokal, R. R. and Rohlf, F. J. 1969. Biometry. Freeman. San Francisco.

Southwood, T. R. E. 1966. Ecological methods. Methuen. London.

Sparks, D. R. and Malechek, J. C. 1968. Estimating percentage dry weight in diets using a microscopic technique. J. Range. Manage. 21: 264-265.

Spinage, C. A. 1973. A review of the age determination of mammals by means of teeth, with special reference to Africa. E. Afr. Wildl. J. 11: 165-187.

Spinage, C. A. 1974. Territoriality and population regulation in the Uganda defassa waterbuck. In Geist, V. and Walther, F. (Eds) The Behaviour of Ungulates and its Relation to Management. pp. 635-644. I.U.C.N. 24.

Squires, V. R. 1965. Ecology and behaviour of domestic sheep, (Ovis aries): A review. Mammal Rev. 5: 35-37.

Staines, B. W. 1974. A review of factors affecting deer dispersion and their relevance to management. Mammal Rev. 4: 79-91.

Stewart, D. R. M. 1967. Analysis of plant epidermis in faeces: a technique for studying the food preferences of grazing herbivores. J. app. Ecol. 4: 83-111.

Strandgaard, H. 1972. The roe deer (Capreolus capreolus) population at Kalo and the factors regulating its size. Danish Rev. Game Biol. 7: 1-205.

Swift, R. W. 1948. Deer select the most nutritious forage. J. Wildl. Manage. 12: 109-110.

Szabik, E. 1973. Age estimation of roe deer from different hunting grounds of south-eastern Poland. Acta theriol. 18: 223-236.

Telfer, E. S. 1969. Twig weight diameter relationships for browse species. J. Wildl. Manage. 33: 917-921.

Thetford, F. O. Piepier, R. D. and Nelson, A. B. 1971. Botanical and chemical composition of cattle and sheep diets on pinyon-juniper grassland range. J. Range. Manage. 24: 425-431.

Thomas, D. C. and Bandy, P. J. 1973. Age determination of wild black-tailed deer from dental annulations. J. Wildl. Manage. 37: 232-235.

Thompson, D. A. 1967. Roe deer and forest management. B.Sc. Thesis. University of Edinburgh.

Thomson, B. R. 1966. A roe deer browsing and fraying assessment at Glentress Forest. B.Sc. Thesis. University of Edinburgh.

Todd, J. W. and Hansen, R. M. 1973. Plant fragments in the faeces of bighorns as indicators of food habits. J. Wildl. Manage. 37: 363-366.

University of Durham Observatory. 1974. Daily Meteorological Observations. University of Durham.

Van Den Brink, F. H. 1973. A field guide to the mammals of Britain and Europe. Collins. London.

Verme, L. J. 1962. An automatic tagging device for deer. J. Wildl. Manage. 26: 387-392.

Verme, L. J. 1965. Swamp conifer deer yards in northern Michigan. Their ecology and management. J. Forestry. 63: 523-529.

Von St. Mottl, Z. 1957. The minimum size of roe territories. Zeit fuer Jagdwiss. 3: 64-69. (Read in English Summary).

Watson, A. and Jenkins, D. 1968. Experiments on population control by territorial behaviour in red grouse. J. Anim. Ecol. 37: 595-614.

Watson, A. and Miller, G. R. 1971. Territory size and aggression in a fluctuating red grouse population. J. Anim. Ecol. 40: 367-383.

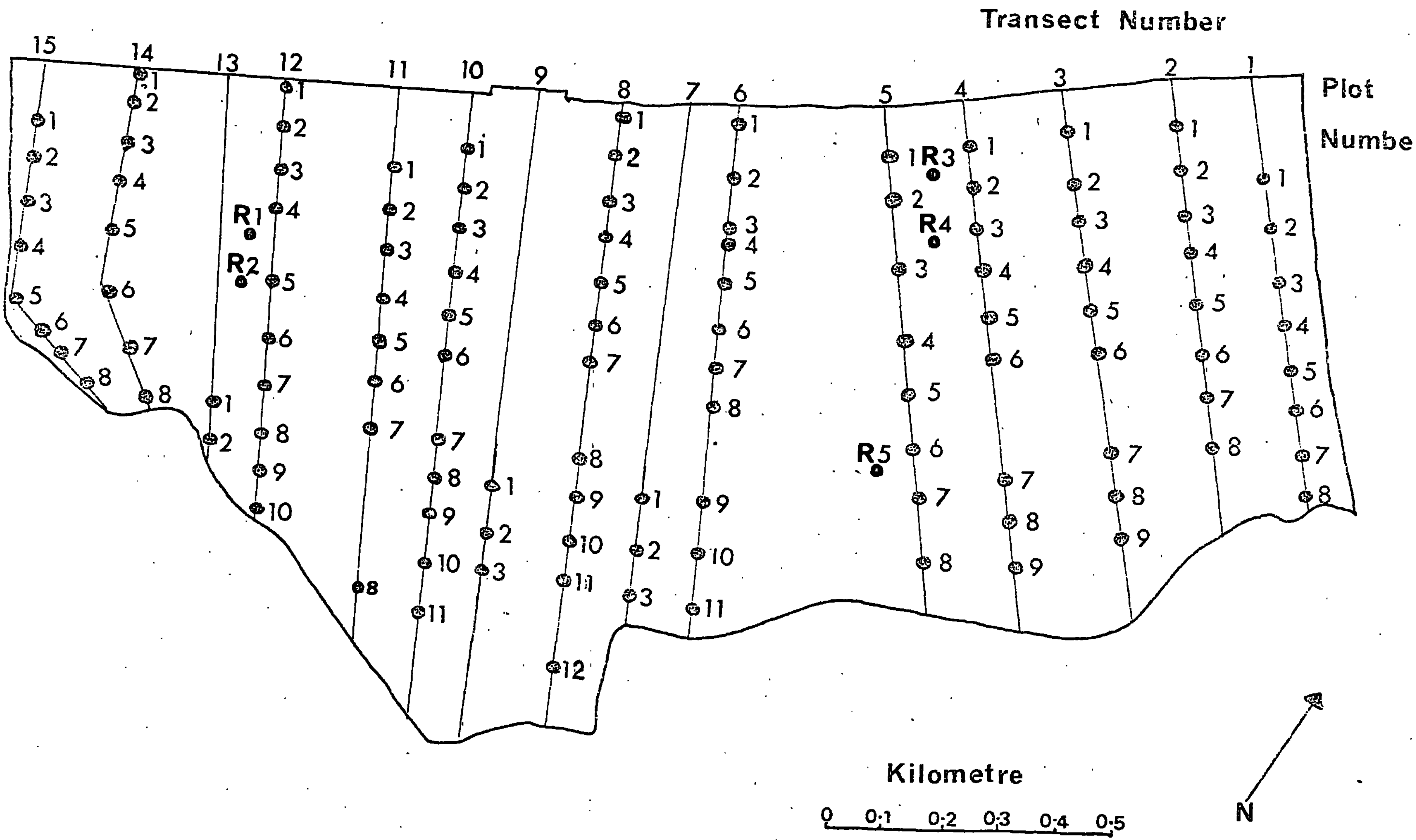
White, G. 1974. Age determination of roe deer (Capreolus capreolus) from annual growth layers in the dental cementum. J. Zool., Lond. 174: 511-516.

White, K. L. 1960. Differential range use by mule deer in the spruce fir zone. Northwest Sci. 34: 118-126.

Wolfe, M. L. 1969. Age determination in moose from cemental layers of molar teeth. J. Wildl. Manage. 33: 428-431.

Zyznar, E. and Urness, P. J. 1969. Qualitative identification of forage remnants in deer faeces. J. Wildl. Manage. 33: 506-510.

Appendix Fig. 1. Approximate locations ● of pellet group plots giving Transect Number and Plot Number. See Appendix 1 for locations of plots by habitat type.



Transect Number
Plot
Number
Kilometre
0 0·1 0·2 0·3 0·4 0·5
N
R1
R2
R3
R4
R5

Appendix 1.

Number of faecal pellet groups and cover readings for each plot during each season.

P = Number of pellet groups; DB = Density board ground cover reading;
C = Canopy cover score; G = Ground cover score.

Mature Spruce Habitat Type

Transect No./	Winter				Spring				Summer				Autumn			
Plot No.	P	DB	C	G	P	DB	C	G	P	DB	C	G	P	DB	C	G
3/1	1	21,3	3	0	1	21,3	3	0	0	21,3	3	0	0	21,3	3	0
3/2	0	18,18	3	0	0	18,18	3	0	0	18,18	3	0	1	18,18	3	0
3/3	1	20,20	3	0	1	20,20	3	0	1	20,20	3	0	0	20,20	3	0
3/4	0	15,0	3	0	0	15,0	3	0	0	15,0	3	0	0	15,0	3	0
3/5	0	14,0	3	0	0	14,0	3	0	0	14,0	3	0	0	14,0	3	0
3/6	2	4,6	3	0	2	4,6	3	0	0	4,6	3	0	0	4,6	3	0
4/1	1	11,0	3	0	0	11,0	3	0	0	11,0	3	0	0	11,0	3	0
4/3	2	0,0	2	0	0	0,0	2	0	1	0,0	2	0	1	0,0	2	0
4/4	0	21,21	3	0	0	21,21	3	0	1	21,21	3	0	0	21,21	3	0
4/5	1	0,0	3	0	1	0,0	3	0	0	0,0	3	0	2	0,0	3	0
4/6	1	16,15	3	0	2	16,15	3	0	1	16,15	3	0	0	16,15	3	0
5/1	0	0,11	3	0	1	0,11	3	0	0	0,11	3	0	0	0,11	3	0
5/2	0	20,20	2	0	0	20,20	2	0	0	20,20	2	0	0	20,20	2	0
5/4	0	21,6	3	0	0	21,6	3	0	0	21,6	3	0	1	21,6	3	0
5/5	2	7,9	3	0	2	7,9	3	0	0	7,9	3	0	3	7,9	3	0
5/6	0	9,0	3	0	1	9,0	3	0	1	9,0	3	0	0	9,0	3	0
5/8	0	21,21	3	0	1	21,21	3	0	0	21,21	3	0	3	21,21	3	0
6/1	1	0,0	3	0	1	0,0	3	0	1	0,0	3	0	0	0,0	3	0
6/2	2	0,21	3	0	0	0,21	3	0	2	0,21	3	0	1	0,21	3	0
6/3	0	20,0	3	0	0	20,0	3	0	0	20,0	3	0	0	20,0	3	0
12/1	0	21,21	3	0	0	21,21	3	0	0	21,21	3	0	0	21,21	3	0
12/2	0	21,21	3	0	0	21,21	3	0	0	21,21	3	0	0	21,21	3	0
12/3	0	20,21	3	0	0	20,21	3	0	0	20,21	3	0	0	20,21	3	0
12/4	0	4,9	3	0	0	4,9	3	0	2	4,9	3	0	0	4,9	3	0
12/5	1	10,10	1	0	1	10,10	1	0	1	10,10	1	0	2	10,10	1	0
12/6	1	18,0	3	0	0	18,0	3	0	0	18,0	3	0	3	18,0	3	0
12/7	1	21,0	3	0	2	21,0	3	0	1	21,0	3	0	0	21,0	3	0
12/8	0	21,20	3	0	1	21,20	3	0	0	21,20	3	0	0	21,20	3	0
14/1	1	0,0	3	0	1	0,0	3	0	0	0,0	3	0	0	0,0	3	0

/continued

Appendix 1 cont'd.

Mature Spruce Habitat Type

Transect No. / Plot No.	Winter				Spring				Summer				Autumn			
	P	DB	C	G	P	DB	C	G	P	DB	C	G	P	DB	C	G
14/6	0	20,17	3	0	1	20,17	3	0	0	20,17	3	0	0	20,17	3	0
15/1	0	20,8	3	0	0	20,18	3	0	1	20,18	3	0	0	20,18	3	0
15/2	1	7,0	3	0	0	7,0	3	0	0	7,0	3	0	0	7,0	3	0
15/3	0	21,21	3	0	0	21,21	3	0	0	21,21	3	0	0	21,21	3	0
15/4	0	18,18	2	0	0	18,18	2	0	0	18,18	2	0	1	18,18	2	0
Mature Pine Habitat Type																
4/2	3	9,8	2	1	0	9,8	2	1	1	9,8	2	1	0	9,8	2	1
5/7	1	20,0	2	1	1	20,0	3	1	1	20,0	3	1	1	20,0	2	1
15/5	0	21,0	1	1	0	21,0	2	1	0	21,0	2	1	1	21,1	1	1
15/6	1	20,20	1	1	1	14,16	2	2	1	14,16	2	2	2	19,18	1	1
15/7	0	15,0	1	1	0	15,0	2	1	0	15,0	2	2	0	15,0	1	1
15/8	1	20,20	1	1	1	18,18	2	2	0	18,18	2	2	1	18,18	1	1
Deciduous Habitat Type																
12/9	0	9,9	1	1	0	17,7	3	3	1	18,18	3	2	0	18,18	1	2
12/10	0	3,0	1	1	0	0,0	3	3	0	0,0	3	2	1	9,9	1	2
14/2	1	21,15	1	1	0	21,15	2	1	0	21,15	2	1	1	21,18	1	1
14/3	0	21,10	1	1	0	7,7	2	3	0	12,7	2	2	0	21,10	1	1
14/4	0	21,0	1	1	0	6,0	2	3	0	6,0	2	3	0	9,0	1	1
14/5	0	11,11	1	1	1	4,7	3	3	1	9,12	3	3	0	9,9	1	1
14/7	0	10,9	1	1	0	7,7	3	1	2	6,9	3	1	0	10,6	1	1
8/12	1	20,20	1	1	0	18,15	3	2	0	20,18	3	1	0	20,18	1	1
11/8	0	14,4	1	1	1	0,0	2	2	0	0,0	2	2	0	14,4	1	1
13/1	0	21,21	1	1	0	18,18	2	1	1	18,18	2	1	0	21,21	1	1
13/2	0	20,18	1	1	0	18,20	2	1	0	20,18	2	1	0	20,18	1	1
14/8	0	10,15	1	1	0	0,0	1	3	0	0,0	1	3	1	18,18	1	1

Appendix 1 cont'd.

Plantation Habitat Type

Transect No.	Winter				Spring				Summer				Autumn			
Plot No.	P	DB	C	G	P	DB	C	G	P	DB	C	G	P	DB	C	G
6/9	0	15,14	0	2	0	11,6	0	3	1	11,6	0	3	2	6,6	0	2
6/10	0	10,10	0	2	2	11,6	0	3	1	6,6	0	3	0	6,6	0	2
6/11	1	15,5	0	2	1	11,6	0	3	2	11,6	0	3	0	6,6	0	2
7/1	0	15,15	0	2	1	11,15	0	3	2	11,15	0	3	2	11,15	0	2
7/2	1	18,11	0	2	3	6,0	0	3	3	6,0	0	3	3	6,0	0	3
7/3	1	6,0	0	2	0	6,0	0	3	2	6,0	0	3	2	0,0	0	2
8/8	0	6,15	0	2	0	0,11	0	3	1	0,15	0	3	0	6,11	0	2
8/9	0	6,0	0	2	1	6,0	0	3	0	0,0	0	3	-	-	-	-
8/10	1	11,11	0	1	0	11,15	0	2	2	18,20	0	2	3	18,18	0	1
8/11	1	21,21	0	1	0	20,20	0	1	0	20,20	0	1	0	20,20	0	1
9/1	0	10,18	0	2	1	6,11	0	3	2	0,15	0	3	1	0,15	0	2
9/2	4	10,15	0	2	1	11,11	0	3	1	0,0	0	3	1	0,0	0	2
9/3	5	20,11	0	2	2	15,6	0	3	1	6,6	0	3	2	0,6	0	2
10/7	0	18,11	0	2	0	11,0	0	3	1	11,0	0	3	3	11,0	0	2
10/8	4	9,6	0	2	1	0,6	0	3	3	6,0	0	3	-	-	-	-
10/9	2	15,11	0	2	2	15,11	0	3	2	15,6	0	3	3	11,6	0	2
10/10	1	18,18	0	2	1	18,18	0	3	1	18,20	0	3	1	20,20	0	2
10/11	0	10,5	0	2	0	0,6	0	3	1	11,0	0	3	2	0,6	0	2

Clearings Habitat Type

Plot No.	P	DB	C	G	P	DB	C	G	P	DB	C	G	P	DB	C	G
1/1	3	20,20	0	1	0	20,20	0	1	3	20,21	0	1	3	20,21	0	1
1/2	4	21,21	0	1	0	20,19	0	1	2	18,18	0	1	3	21,21	0	1
1/3	1	21,21	0	1	1	21,21	0	1	0	21,21	0	1	0	21,21	0	1
1/4	0	20,20	0	1	1	20,20	0	1	1	18,20	0	1	1	18,20	0	1
1/5	3	18,18	0	1	3	18,18	0	1	1	18,18	0	1	0	20,18	0	1
1/6	2	21,21	0	1	0	20,21	0	1	2	19,20	0	1	1	21,21	0	1
1/7	3	20,21	0	1	0	20,21	0	1	1	20,20	0	1	2	20,21	0	1
1/8	0	20,20	0	1	0	11,11	0	3	0	18,18	0	1	1	18,20	0	1
2/1	2	20,20	0	1	1	20,20	0	1	2	21,21	0	1	2	21,20	0	1
2/2	2	20,18	0	1	1	20,18	0	1	2	20,20	0	1	4	20,18	0	1
2/3	0	20,20	0	1	0	20,19	0	1	0	18,18	0	1	1	18,15	0	1
2/4	0	18,15	0	1	0	15,15	0	1	0	15,15	0	1	0	18,15	0	1
2/5	3	20,20	0	1	4	18,18	0	1	3	18,18	0	1	4	18,18	0	1

/continued

Appendix 1 cont'd.

Clearings Habitat Type

Transect No. / Plot No.	Winter P	Winter DB	Winter C	Winter G	Spring P	Spring DB	Spring C	Spring G	Summer P	Summer DB	Summer C	Summer G	Autumn P	Autumn DB	Autumn C	Autumn G
2/6	2	20,20	0	1	0	18,20	0	1	0	20,20	0	1	2	20,20	0	1
2/7	1	6,15	0	3	3	6,15	0	3	4	6,15	0	3	1	6,15	0	3
2/8	1	18,20	0	1	1	18,18	0	1	4	18,18	0	1	0	18,20	0	1
3/7	0	20,18	0	1	0	15,20	0	1	1	15,20	0	1	0	20,19	0	1
3/8	4	20,20	0	1	3	19,20	0	1	1	20,18	0	1	2	20,21	0	1
3/9	0	21,21	0	1	2	20,21	0	1	1	21,21	0	1	3	21,21	0	1
4/7	4	21,21	0	1	1	21,20	0	1	1	21,20	0	1	1	21,21	0	1
4/8	0	18,18	0	1	2	18,20	0	1	2	18,20	0	1	2	18,15	0	1
4/9	1	20,20	0	1	2	20,20	0	1	3	20,21	0	1	0	20,21	0	1
5/3	4	20,18	0	2	2	18,18	0	2	1	20,18	0	3	2	20,18	0	2
11/1	2	18,20	0	1	1	15,18	0	1	1	15,18	0	1	3	18,18	0	1
11/2	2	20,20	0	1	2	20,20	0	1	3	20,18	0	1	0	20,20	0	1
11/3	2	20,20	0	1	3	20,20	0	1	2	20,20	0	1	1	20,20	0	1
11/4	2	21,21	0	1	1	20,21	0	1	4	20,20	0	1	1	20,20	0	1
11/5	1	18,21	0	1	1	18,20	0	1	1	18,20	0	1	2	20,20	0	1
11/6	0	15,18	0	1	1	18,18	0	1	1	15,18	0	2	0	15,15	0	2
11/7	1	18,18	0	1	0	15,15	0	2	0	20,18	0	2	2	20,18	0	2
Rides Habitat Type																
R/1	2	21,21	0	1	5	15,15	0	3	4	18,18	0	1	3	20,20	0	1
R/2	1	21,21	0	1	1	20,20	0	1	3	20,20	0	1	2	21,20	0	1
R/3	5	20,20	0	1	5	20,20	0	1	2	20,20	0	1	4	20,20	0	1
R/4	2	20,20	0	1	1	15,19	0	1	2	20,20	0	1	2	21,21	0	1
R/5	3	20,20	0	1	1	19,19	0	1	3	20,18	0	1	2	20,20	0	1

Fields Habitat Type

No data are available for this habitat. See Section 3.3.1.

Appendix 1 cont'd.

Deer faecal pellet group counts; Area sampled per habitat type.

Habitat Type	Area in Hectares	Sampled Area in m^2	Sampled Area as % of Habitat area
Mature Spruce	66.1	1700	0.3
Mature Pine	56.5	1500	0.3
Deciduous	28.4	900[1]	0.3
Plantation	16.0	600	0.4
Clearings	4.7	300	0.6
Rides	1.7	250	1.5
Fields[2]	39.7	950	0.2

1. 800 m^2 in the autumn

2. Abandoned

Season	Total Area Sampled (m^2)
Winter	6200
Spring	5250
Summer	5250
Autumn	5150

Appendix 2.

Comparison of observed pellet group frequencies with the Poisson distribution using the Coefficient of Dispersion and employing the following equation from Southwood (1968).

$$X^2 = \frac{s^2(n - 1)}{\bar{x}} \quad \text{at } n - 1 \text{ degrees of freedom.}$$

Analysis of pellet group frequencies for the entire study area. Sample size = 105 for winter, spring and summer but 103 in autumn.

	Observed frequencies			
No. pellet groups/ plot	Winter	Spring	Summer	Autumn
0	47	47	42	46
1	29	36	34	22
2	15	12	17	20
3	6	7	8	12
4	6	1	4	3
5	2	2	0	0

	Variance s^2	Mean $\bar{x}$	Coefficient of Dispersion	Calculated X^2	Significance Level
Winter	1.65	1.06	1.56	162.44	$P < 0.05$
Spring	1.22	0.90	1.35	140.42	$P < 0.05$
Summer	1.22	1.03	1.19	123.50	$P > 0.05$
Autumn	1.38	1.07	1.29	131.61	$P < 0.05$

For the entire study area, the characteristics of a Poisson distribution exist only during the summer. There is evidence of clumping in all other seasons.

Appendix 2 cont'd.

Mature Spruce Habitat Type. n = 34

No. pellet groups/ plot	Observed frequencies Winter	Spring	Summer	Autumn
0	19	19	23	24
1	11	11	9	5
2	4	4	2	2
3	0	0	0	3

	Variance (S^2)	Mean ($\bar{x}$)	Coefficient of Dispersion	Calculated X^2	Significance level
Winter	0.49	0.59	0.88	29.33	P > 0.05
Spring	0.49	0.59	0.88	29.33	"
Summer	0.36	0.38	0.95	31.44	"
Autumn	0.38	0.53	0.71	23.51	"

For the mature spruce habitat type, the characteristics of a Poisson distribution exist during each season.

Mature Pine Habitat Type n = 6

No. pellet groups/ plot	Observed Frequencies Winter	Spring	Summer	Autumn
0	2	3	3	2
1	3	3	3	3
2	0	0	0	1
3	1	0	0	0

	Variance (S^2)	Mean ($\bar{x}$)	Coefficient of Dispersion	Calculated X^2	Significance Level
Winter	1.20	1.00	1.2	6.00	P > 0.05
Spring	0.30	0.50	0.60	3.00	"
Summer	0.30	0.50	0.60	3.00	"
Autumn	0.57	0.83	0.68	3.40	"

For the mature pine habitat type, the characteristics of a Poisson distribution exist during each session.

Appendix 2 cont'd.

Deciduous Habitat Type   n = 12

No. pellet groups/ plot	Observed Frequencies Winter	Spring	Summer	Autumn
0	10	10	8	9
1	2	2	3	3
2	0	0	1	0

	Variance (S^2)	Mean ($\bar{x}$)	Coefficient of Dispersion	Calculated X^2	Significance Level
Winter	0.15	0.16	0.91	10.01	$P > 0.05$
Spring	0.15	0.16	0.91	10.01	"
Summer	0.45	0.42	1.07	11.79	"
Autumn	0.20	0.25	0.82	9.02	"

For the deciduous habitat type, the characteristics of a Poisson distribution exist during each season.

Plantation Habitat Type   n = 18; 16 in autumn

No. pellet groups/ plot	Observed Frequencies Winter	Spring	Summer	Autumn
0	8	7	2	3
1	6	7	8	3
2	1	3	6	6
3	0	1	2	4
4	2	0	0	0
5	1	0	0	0

	Variance (S^2)	Mean ($\bar{x}$)	Coefficient of Dispersion	Calculated X^2	Significance Level
Winter	2.5	1.16	2.15	36.63	$P < 0.05$
Spring	0.81	0.88	0.91	15.60	$P > 0.05$
Summer	0.73	1.44	0.51	8.64	"
Autumn	1.16	1.68	0.68	10.33	"

For the plantation habitat type, the characteristics of a Poisson distribution exist during each season except winter, when clumping was evident.

Appendix 2 cont'd.

Clearings Habitat Type n = 30.

No. pellet groups/ plot	Observed Frequencies Winter	Spring	Summer	Autumn
0	8	10	6	8
1	6	10	11	8
2	8	5	6	8
3	4	4	4	4
4	4	1	3	2

	Variance (S^2)	Mean ($\bar{x}$)	Coefficient of Dispersion	Calculated X^2	Significance Level
Winter	1.88	1.66	1.13	32.84	$P > 0.05$
Spring	1.34	1.20	1.11	32.31	"
Summer	1.56	1.56	0.99	28.94	"
Autumn	1.49	1.46	1.02	29.75	"

For the clearings habitat type, the characteristics of a Poisson distribution exist during each season.

Rides Habitat Type n = 5

No. pellet groups/ plot	Observed Frequencies Winter	Spring	Summer	Autumn
0	0	0	0	0
1	1	3	0	0
2	2	0	2	3
3	1	0	2	1
4	0	0	1	1
5	1	2	0	0

	Variance (S^2)	Mean ($\bar{x}$)	Coefficient of Dispersion	Calculated X^2	Significance Level
Winter	2.30	2.60	0.88	3.53	$P > 0.05$
Spring	4.80	2.60	1.85	7.38	"
Summer	0.70	2.80	0.25	1.00	"
Autumn	0.80	2.50	0.31	1.23	"

For the rides habitat, the characteristics of a Poisson distribution exist during each season.

Appendix 3.

Percentage density of plant types on faecal pellet group plots and presence or absence of herbs and mosses.

G = Grasses and grasslike plants; C = <u>Calluna vulgaris</u>; P = <u>Picea sitchensis</u>; h = herbs; m = mosses; ✓ denotes presence of herbs or mosses.

Mature Spruce Habitat Type

Transect No.	Winter					Spring					Summer					Autumn				
Plot No.	G	C	P	h	m	G	C	P	h	m	G	C	P	h	m	G	C	P	h	m
3/1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/5	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓
3/6	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓
4/1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/3	0	0	0	✓	✓	0	0	0	✓	✓	0	0	0	✓	✓	0	0	0	✓	✓
4/4	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓
4/5	0	0	0	✓	✓	0	0	0	✓	✓	0	0	0	✓	✓	0	0	0	✓	✓
4/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/1	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓
5/2	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓
5/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/5	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓
5/6	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓
5/8	5	5	0	0	✓	15	5	0	0	✓	15	5	0	0	✓	5	5	0	0	✓
6/1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/3	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓
12/1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/5	5	0	0	0	✓	15	0	0	0	✓	15	0	0	0	✓	5	0	0	0	✓
12/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/8	0	0	0	0	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓	0
14/1	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓
14/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

/continued

Appendix 3 cont'd.

Mature Spruce Habitat Type

Transect No. / Plot No.	Winter G	C	P	h	m	Spring G	C	P	h	m	Summer G	C	P	h	m	Autumn G	C	P	h	m
15/1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15/2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15/3	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓	0	0	0	0	✓	0
15/4	5	0	0	0	✓	15	0	0	0	✓	15	0	0	0	✓	5	0	0	0	✓
Mature Pine Habitat Type																				
4/2	15	0	0	0	✓	25	0	0	0	✓	25	0	0	0	✓	15	0	0	0	✓
5/7	75	0	0	✓	0	85	0	0	✓	0	85	0	0	✓	0	85	0	0	✓	0
15/5	85	0	0	0	0	95	0	0	0	0	75	0	0	0	0	85	0	0	0	0
15/6	75	0	0	✓	0	85	0	0	✓	0	85	0	0	✓	0	75	0	0	✓	0
15/7	25	0	0	0	0	35	0	0	0	0	35	0	0	0	0	25	0	0	0	0
15/8	85	0	0	✓	0	95	0	0	✓	0	95	0	0	✓	0	85	0	0	✓	0
Deciduous Habitat Type																				
12/9	65	0	0	✓	0	75	0	0	✓	0	75	0	0	✓	0	65	0	0	✓	0
12/10	65	0	0	✓	0	75	0	0	✓	0	75	0	0	✓	0	65	0	0	✓	0
14/2	85	0	0	0	0	95	0	0	0	0	95	0	0	0	0	85	0	0	0	0
14/3	25	0	0	✓	0	35	0	0	✓	0	35	0	0	✓	0	25	0	0	✓	0
14/4	85	0	0	0	0	95	0	0	0	0	95	0	0	0	0	85	0	0	0	0
14/5	95	5	0	✓	0	95	5	0	✓	0	95	5	0	✓	0	95	5	0	✓	0
14/7	85	0	0	0	0	95	0	0	0	0	95	0	0	0	0	95	0	0	0	0
8/12	45	0	0	✓	0	65	0	0	✓	0	75	0	0	✓	0	55	0	0	✓	0
11/8	85	0	0	✓	0	95	0	0	✓	0	95	0	0	✓	0	95	0	0	✓	0
13/1	75	0	0	✓	✓	95	0	0	✓	✓	95	0	0	✓	✓	85	0	0	✓	✓
13/2	25	0	0	✓	0	35	0	0	✓	✓	35	0	0	✓	✓	25	0	0	✓	✓
14/8	95	0	0	✓	0	95	0	0	✓	0	95	0	0	✓	0	95	0	0	✓	0
Plantation Habitat Type																				
6/9	75	0	65	✓	0	85	0	75	✓	0	85	0	75	✓	0	75	0	75	✓	0
6/10	5	85	35	0	✓	15	85	45	0	✓	15	85	45	0	✓	5	85	45	0	✓
6/11	15	55	45	✓	✓	25	65	55	✓	✓	25	65	55	✓	✓	15	65	55	✓	✓
7/1	35	5	75	✓	0	45	15	85	✓	0	45	5	85	✓	0	35	5	85	✓	0
7/2	55	25	55	✓	0	65	25	65	✓	0	65	25	65	✓	0	55	25	65	✓	0
7/3	75	5	35	0	0	85	5	45	0	0	85	5	45	0	0	75	5	45	0	0
8/1	85	0	25	✓	✓	95	0	35	✓	✓	95	0	35	✓	✓	85	0	35	✓	✓
8/2	85	0	55	✓	✓	95	0	65	✓	✓	95	0	65	✓	✓	-	-	-	-	-

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Appendix 3 cont'd.

Plantation Habitat Type

Transect No. / Plot No.	Winter G	Winter C	Winter P	Winter h	Winter m	Spring G	Spring C	Spring P	Spring h	Spring m	Summer G	Summer C	Summer P	Summer h	Summer m	Autumn G	Autumn C	Autumn P	Autumn h	Autumn m
8/3	85	0	25	✓	0	95	0	35	✓	0	95	0	35	✓	0	85	0	35	✓	0
8/4	95	0	0	✓	0	95	0	0	✓	0	95	0	0	✓	0	85	0	0	✓	0
9/1	75	15	35	✓	0	85	15	45	✓	0	85	15	45	✓	0	75	15	45	✓	0
9/2	65	15	45	✓	0	75	15	55	✓	0	75	15	55	✓	0	65	15	55	✓	0
9/3	75	0	55	✓	0	85	0	65	✓	0	85	0	65	✓	0	75	0	65	✓	0
10/7	55	5	35	✓	0	65	5	45	✓	0	65	5	45	✓	0	55	5	45	✓	0
10/8	65	45	45	✓	✓	75	45	55	✓	✓	75	45	55	✓	✓	-	-	-	-	-
10/9	85	5	45	✓	0	95	5	55	✓	0	95	5	55	✓	0	85	5	55	✓	0
10/10	15	95	5	0	✓	25	95	15	✓	0	25	95	15	0	✓	15	95	15	0	✓
10/11	65	15	35	✓	0	75	15	45	✓	0	75	15	45	✓	0	65	15	45	✓	0

Clearings Habitat Type

Transect No. / Plot No.	Winter G	Winter C	Winter P	Winter h	Winter m	Spring G	Spring C	Spring P	Spring h	Spring m	Summer G	Summer C	Summer P	Summer h	Summer m	Autumn G	Autumn C	Autumn P	Autumn h	Autumn m
1/1	65	25	0	0	0	85	25	0	0	0	95	25	0	0	0	85	25	0	0	0
1/2	75	5	0	0	✓	85	5	0	0	✓	85	5	0	0	✓	75	5	0	0	✓
1/3	10	0	5	0	0	30	0	5	0	0	30	0	5	0	0	20	0	5	0	0
1/4	0	0	35	0	0	0	0	45	0	0	0	0	45	0	0	0	0	45	0	0
1/5	60	25	15	0	✓	80	35	25	0	✓	80	35	25	0	✓	70	35	25	0	✓
1/6	30	25	35	0	0	50	25	45	0	0	50	25	45	0	0	50	25	45	0	0
1/7	50	25	45	0	0	70	25	55	0	0	70	25	55	0	0	70	25	55	0	0
1/8	15	0	45	0	0	35	0	55	0	0	35	0	55	0	0	25	0	55	0	0
2/1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/2	0	5	5	0	0	0	5	5	0	0	0	5	5	0	0	0	5	5	0	0
2/3	20	5	5	0	✓	30	15	5	0	✓	30	15	5	0	✓	30	15	5	0	✓
2/4	35	15	35	0	✓	45	15	35	0	✓	45	15	35	0	✓	35	15	35	0	✓
2/5	50	15	25	0	✓	70	25	35	0	✓	70	25	35	0	✓	50	25	35	0	✓
2/6	30	15	5	0	0	50	25	5	0	0	50	25	5	0	0	40	25	5	0	0
2/7	35	5	45	✓	✓	65	15	55	✓	✓	65	15	55	✓	✓	45	15	55	✓	✓
2/8	45	5	25	✓	✓	55	15	35	✓	✓	55	15	35	✓	✓	45	15	35	✓	✓
3/7	15	5	5	✓	✓	25	15	5	✓	✓	25	15	5	✓	✓	25	15	5	✓	✓
3/8	10	5	15	✓	✓	20	5	15	✓	✓	20	5	15	✓	✓	10	5	15	✓	✓
3/9	15	15	0	0	✓	25	25	0	0	✓	25	25	0	0	✓	15	25	0	0	✓
4/7	15	15	5	0	✓	25	25	5	0	✓	25	25	5	0	✓	25	25	5	0	✓
4/8	5	5	5	0	✓	15	5	5	0	✓	15	5	5	0	✓	5	5	5	0	✓
4/9	5	0	0	0	0	5	0	0	0	0	5	0	0	0	0	5	0	0	0	✓

/continued

Appendix 3 cont'd.

Clearings Habitat Type

Transect No. / Plot No.	Winter G	Winter C	Winter P	Winter h	Winter m	Spring G	Spring C	Spring P	Spring h	Spring m	Summer G	Summer C	Summer P	Summer h	Summer m	Autumn G	Autumn C	Autumn P	Autumn h	Autumn m
5/3	45	35	0	0	✓	55	45	0	0	✓	55	45	0	0	✓	45	45	0	0	✓
11/1	75	5	35	0	0	85	15	45	0	0	85	15	45	0	0	75	15	45	0	0
11/2	55	5	5	✓	0	65	15	15	✓	0	65	15	15	✓	0	55	15	15	✓	0
11/3	55	45	15	✓	0	75	55	25	✓	0	75	55	25	✓	0	65	55	25	✓	0
11/4	65	45	5	✓	0	85	55	15	✓	0	85	55	15	✓	0	75	55	15	✓	0
11/5	55	0	5	✓	0	65	0	15	✓	0	65	0	15	✓	0	55	0	15	✓	0
11/6	55	0	15	✓	✓	75	0	25	✓	✓	75	0	25	✓	✓	65	0	25	✓	✓
11/7	45	0	5	✓	0	55	0	15	✓	0	55	0	15	✓	0	45	0	15	✓	0
Rides Habitat Type																				
R/1	55	35	0	✓	0	65	35	0	✓	0	65	35	0	✓	0	55	35	0	✓	0
R/2	85	5	0	✓	0	95	5	0	✓	0	95	5	0	✓	0	85	5	0	✓	0
R/3	65	85	0	0	0	75	85	0	✓	0	75	85	0	✓	0	65	85	0	0	0
R/4	65	75	0	✓	0	75	75	0	✓	0	75	75	0	✓	0	65	75	0	✓	0
R/5	85	5	0	0	✓	95	5	0	0	✓	95	5	0	0	✓	85	5	0	0	✓

Appendix 4.

Kruskal-Wallis single classification anova to test for significant differences in the number of pellet groups per plot within the plantation habitat among seasons; and among all habitats in winter. Since this is a non-parametric anova which uses ranks, the null hypotheses are as follows, (see Sokal and Rohlf 1969):

1. That there was no difference in the location of the ranked data within the plantation habitat type among seasons.

(No. of seasons = 4 $\therefore$ d.f. = 4-1)
calculated H = 7.36 which is less than $\chi^2_{.05(3)} = 7.81$

Therefore the null hypothesis is accepted and the conclusion is that there was no difference in the number of pellet groups per plot within the plantation habitat type among seasons.

2. That there was no difference in the location of the ranked data among habitat types during the winter.

(No. of habitat types = 6 $\therefore$ d.f. = 6-1)
Calculated H = 25.28 which is greater than $\chi^2_{.05(5)} = 11.07$

Therefore the null hypothesis is rejected and the conclusion is that there were significant differences in the number of pellet groups per plot between habitat types during the winter.

Both of these conclusions agree with those derived using the parametric single classification anova using transformed data in Section 3.3.1.

Appendix 5.

Results of using the self-attaching collar technique and ear tagging of kids.

From March 15 to December 15 1973, and from April 1 to May 15 1974, about 50 collars were constantly maintained in positions in selected deer paths.

Number of collars taken in 1973	= 22
Number of " " " " observed on deer in 1973	= 7
" " " " " " " " " " 1974	= 3
" " " " " 1974	= 3
" " " " " " " " " " "	= 0

Number of kids tagged in 1973 = 5 (2 does, 3 bucks)

" " " " " 1974 = 3 (1 doe, 2 bucks)

Appendix 6.

Percentage frequency of occurrence and availability factors of plant species in the study area by habitat.

Plant Species	Mature Spruce		Mature Pine		Deciduous		Thicket		Clearings		Rides		Overall % Occurrence and Availability Factor			
	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	AF*	1974 %	AF
TREES[c.]																
Betula sp.	0	0	0	0	0[a.]	0[a.]	0[a.]	0[a.]	0	0	0	0	0	2	0	2
Fagus sylvatica	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Ilex aquifolium	0	0	0	0	0[a.]	0[a.]	0	0	0	0	0	0	0	1	0	1
Larix decidua	0	0	0	0	0[a.]	4	0	0	0	0	0	0	0	2	0	1
Picea abies	0	0	0	0	0	0	0	0	0[a.]	0[a.]	0	0	0	1	0	1
Picea sitchensis	0[a.]	0[a.]	0	0	0	0	36	44	6	11	0	0	8	4	8	4
Pinus contorta	0	0	0[a.]	0[a.]	0	0	0	0	0	0	0	0	0	1	0	1
Pinus sylvestris	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	4
Pseudostuga menziesii	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Quercus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
DWARF SHRUBS																
Calluna vulgaris	0	1	0[a.]	2	0[a.]	4	17	22	16	24	50	54	10	4	16	4
Erica tetralix	0	0	0	0	0	0	0[a.]	0[a.]	0[a.]	1	0[a.]	0[a.]	0	1	0	1
Rubus sp.	0	0	0	0	0	0	0[a.]	0[a.]	0	1	0	0	0	1	0	1
Ulex europaeus	0	0	0	0	0	0	0	0	0	0	2	0[a.]	0	1	0	1
Vaccinium myrtilus	0	1	5	6	5	10	0	0	0	1	8	6	1	2	3	3

/continued

Appendix 6 cont'd.

Plant Species	Mature Spruce		Mature Pine		Deciduous		Thicket		Clearings		Rides		Overall % Occurrence and Availability Factor			
	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	AF*	1974 %	AF
GRASSES																
Agrostis sp.	6[b].	0	0	2	2	0[a].	37	26	22	21	6	6	12	4	10	4
Anthoxanthum odoratum	0	0	0	0	12	6	5	12	0[a].	2	2	0[a].	2	3	2	3
Bromus sp.	0	0	0	0	0	0	0	0	1[b].	0	0	0	0	1	0	1
Cynosaurus cristatus	0	0	0	0	0	0	0[a].	0	0	0	0	0	0	1	0	1
Dactylis glomerata	5[b].	0	0	0	0	0	1	0	2	5	0	2	2	2	2	2
Deschampsia caespitosa	1	0	0	0	0	0	25	26	1	3	0	0	5	3	3	3
Deschampsia flexuosa	2	4	23	26	14	36	6	12	15	26	36	30	11	4	20	4
Festuca sp.	1[b].	1[b].	27	26	27	42	45	56	4	7	32	22	15	4	17	4
Holcus sp.	4[b].	3[b].	0	0	3	12	19	18	6	15	0[a].	6	7	3	9	4
Lolium perenne	0[b].	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Nardus stricta	0	0	0	0	0	0	0	0	0	0	6	0[a].	0	1	0	1
Poa sp.	7[b].	1[b].	2[b].	0	5	8	3	0[a].	2[b].	2[b].	0	2	4	3	2	2
Unidentified grasses	0	0	7	0	12	0	2	0	1	0	0	0	2	2	0	1
GRASSLIKE PLANTS																
Carex sp.	0[a].	11	2	6	8	8	0	0	4	7	5	0[a].	2	2	4	3

/continued

Appendix 6 cont'd.

Plant Species	Mature Spruce		Mature Pine		Deciduous		Thicket		Clearings		Rides		Overall % Occurrence and Availability Factor			
	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	AF*	1974 %	AF
GRASSLIKE PLANTS cont'd.																
<u>Eriophorum vaginatum</u>	0	0	0	0	0	0	0	0	2	5	2	0[a.]	1	2	1	2
<u>Juncus</u> sp.	2	0	0	0	0	0	17	14	17	15	38	40	10	4	10	4
<u>Luzula</u> sp.	0	0	0	0	1	0[a.]	1	8	2	3	4	0[a.]	0	1	2	2
HERBS																
<u>Cirsium</u> sp.	1[b.]	0	0	0	0	0	1[b.]	0	0	1[b.]	0	0	0	1	0	1
<u>Digitalis purpurea</u>	1[b.]	1[b.]	0	0	0	0	0	0	0[b.]	0	0[a.]	4	0	1	0	1
<u>Chamaenerion angustifolium</u>	0	0	0	0	0	0	0	0	0[a.]	1	0[a.]	4	0	1	0	1
<u>Galium saxatile</u>	2	4	5	8	12	20	21	36	8	17	34	40	10	4	17	4
<u>Lotus</u> sp.	0	0	0	0	0	0	0	0	2[b.]	6[b.]	0	0	1	2	2	2
<u>Oxalis acetosella</u>	0	0	18	10	17	10	0	0	0	0	0	0	2	2	2	2
<u>Potentilla erecta</u>	0	0	0	0	0	0	7	10	0	1	8	12	2	2	2	2
<u>Ranunculus</u> sp.	1[b.]	1[b.]	0	0	0	0	1[b.]	0	0	1[b.]	2	2	1	2	0	1
<u>Rumex</u> sp.	0	0	0	2[b.]	0	0	0[a.]	2	1	2	0[a.]	2	0	1	1	2
<u>Silene vulgaris</u>	0[b.]	0	0	0	0	0	0	0	0	0	0[a.]	0	0	1	0	1
<u>Stellaria holostea</u>	1[b.]	1[b.]	0	0	0	0	0	0	0[b.]	0	0	4	0	1	0	1

/continued

Appendix 6 cont'd.

Plant Species	Mature Spruce		Mature Pine		Deciduous		Thicket		Clearings		Rides		Overall % Occurrence and Availability Factor			
	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	AF*	1974 %	AF
HERBS cont'd.																
Trifolium sp.	4[b.]	0	0	0	0	0	2[b.]	0[b.]	2[b.]	2[b.]	0	2[b.]	2	2	1	1
Tussilago farfara	0	0	0	0	0	0	0	0	0[b.]	1[b.]	0	0	0	1	1	2
Urtica dioica	4[b.]	2[b.]	0	0	0	0	0[b.]	0	1[b.]	1[b.]	0	0	2	2	4	3
Verbascum sp.	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1
Veronica scutellata	0	0	0	0	1	4	0	0	0	1	0	0	0	1	1	2
FERNS																
Blechnum spicant	0	1	0[a.]	2	1	0[a.]	0[a.]	0[a.]	0[a.]	0[a.]	0	0	0	1	0	1
Dryopteris sp.	1	1	2	4	1	0[a.]	0	0	1	2	0[a.]	0[a.]	1	1	1	2
Pteridium aquilinium	0	0	20	28	40	40	0[a.]	0[a.]	2	3	6	0[a.]	6	3	8	4
MOSSES																
Atriculum undulatum	0[a.]	0	0	0	2	0[a.]	0	0	0	0	0	0	0	1	0	1
Hylocomium splendens	4	7	0	0	0	0	1	0	1	0	0	0	2	2	2	2
Mnium hornum	1	5	0[a.]	2	5	0[a.]	0	0	0	1	0	0	1	2	2	2
Plagiothecium undulatum	8	13	8	10	0	0	0	0	1	3	0	0	3	2	6	3
Polytrichium sp.	1	5	8	4	0	0	4	6	2	9	6	10	2	2	6	3
Rhytidiadelphus squarrosus	0	0	0	4	2	0	1	2	0	0	0	0	30	1	1	2

/continued

Appendix 6 cont'd.

Plant Species	Mature Spruce		Mature Pine		Deciduous		Thicket		Clearings		Rides		Overall % Occurrence and Availability Factor			
MOSSES cont'd.	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	1974 %	1973 %	AF*	1974 %	AF
Sphagnum sp.	1	5	0[a]	4	0	0	2	2	1	4	14	6	1	2	4	3
Other Mosses	0	3	0	0	7	0[a]	0	0	4	1	0	0	2	2	1	2
TOTAL	15	38	16	24	16	0	8	10	9	18	20	16				
Total point quadrats	410	150	60	50	120	50	220	50	360	150	50	50	1220		500	
Total hits on all plants	236	85	85	77	214	102	556	161	483	299	143	132	1717		856	

[a]. Missed during sampling but presence noted.

[b]. Presence noted at edge of habitat

[c]. I believe that the availability of all tree species in the study area was probably under-representative of their availability in the forest as a whole. Therefore, availability factors for individual trees are assigned based on my subjective assessment of their availability. Availability factors for the following species, present in other parts of the forest, but absent from the study area, are similarly assigned: Crepis sp. 1; Fungi 1; Pyrola sp. 1; Endymion non-scriptus 1; Plantago sp. 2.

*AF = Availability Factor

% Frequency	Availability Factor
0 - 5	1
.51 - 2.5	2
2.51 - 7.5	3
> 7.5	4

Appendix 7. Westmoor Plantation Preliminary Clipping Data.
March 1974. Ten 0.25 $m.^2$ plots/habitat.

Habitat Type.	Total air dried weight of annual plant production in g./plot.
Birch Pine	11.5, 4.5, 9.5, 18.5, 17.0, 28.5, 9.0, 13.0, 24.0, 16.5
Scots Pine	12.0, 22.5, 19.0, 14.0, 19.0, 17.0, 28.5, 21.0, 10.0, 18.5
Larch	25.0, 8.0, 34.0, 22.0, 29.5, 20.0, 16.0, 22.0, 28.0, 14.0
Fir Spruce	26.5, 34.0, 30.0, 23.0, 44.0, 20.0, 40.0, 41.0, 20.0, 38.5
Plantation	25.0, 23.5, 26.0, 28.5, 38.5, 25.5, 22.0, 20.0, 20.0, 38.0
Rides	11.5, 4.5, 9.5, 18.5, 17.0, 28.5, 9.0, 13.0, 24.0, 16.5

September Chipping

Total oven dried weight in g./enclosed and g./open plot for all plant species in each habitat type.
Enclosed Open

Birch Pine n = 34	0.31, 0.51; 0.43, 0.43; 0.24, 0.49; 0.43, 0.42; 0.40, 0.66; 0.26, 0.48; 1.26,0.14; 0.76, 0.92; 0.34, 0.40; 0.27, 0.31; 0.34, 0.53; 0.41, 0.37; 0.41, 0.31; 0.35, 0.43; 0.26, 0.13; 0.45, 0.55; 0.26, 0.34:
Scots Pine n = 24	0.10, 0.08; 0.32, 0.28; 0.06, 0.05; 0.06, 0.11; 0.17, 0.08; 0.09, 0.09; 0.16, 0.08; 0.21, 0.16; 0.40, 0.23; 0.17, 0.35; 0.22, 0.21; 0.12, 0.11;
Larch n = 32	0.19, 0.11; 0.96, 0.57; 0.41, 1.15; 1.00, 0.63; 2.06, 3.57; 3.70, 3.11; 1.21, 0.59; 1.05, 0.44; 0.14, 0.67; 0.18, 0.22; 0.32, 0.17; 0.16, 0.20; 0.05, 0.05; 0.07, 0.13; 0.24, 0.24; 0.40, 0.11;
Fir Spruce n = 14	0.43, 0.61; 0.50, 0.84; 1.80, 0.88; 0.83, 0.87; 1.25, 1.10; 2.93, 2.56; 1.17, 1.06;
Plantation n = 16	2.50, 2.30; 1.50, 1.06; 2.30, 0.98; 2.50, 2.50; 1.86, 1.55; 0.69, 1.26; 2.00, 2.30; 1.65, 0.50;
Rides n = 30	1.48, 2.58; 1.50, 0.78; 2.83, 2.51; 2.35, 1.92; 2.00, 1.50; 0.99, 1.09; 0.88, 0.51; 0.66, 0.73; 1.96, 2.07; 2.12, 0.82; 2.07, 1.87; 0.67, 0.74; 0.13, 0.36; 0.86, 0.58; 1.25, 1.04;

Note: The weights of the air dried vegetation which was clipped in March were much greater than those for the September study. It is suspected that this is because a spiral spring balance used to weigh the air dried vegetation, clipped in March, was inaccurate.

Appendix 7 cont'd.

Total oven dried weight in grams of plant species clipped on all enclosed plots (E) and open plots (O) in each habitat type.

Species	Habitat Type	
	Birch Pine	
	(E)	(O)
Deschampsia flexuosa	2.3	4.4
Galium saxatile	0.2	0
Grasses and grasslike plants	1.6	1.7
Holcus sp.	0.5	0.4
Oxalis acetosella	0.2	0.2
Pteridium aquilinium	1.4	0.4
Vaccinium myrtilus	0	0.1
	Scots Pine	
Deschampsia flexuosa	1.4	1.6
Pinus sylvestris	0.2	0.2
Vaccinium myrtilus	0.5	0.2
	Larch	
Betula sp.	0.2	0
Deschampsia flexuosa	1.9	1.8
Grasses and grasslike plants	2.5	2.6
Larix decidua	0.8	0.3
Mosses	0.3	0.2
Pteridium aquilinium	2.0	3.8
Vaccinium myrtilus	0.3	0.1
	Fir Spruce	
Calluna vulgaris	0.3	0.8
Deschampsia flexuosa	0.4	0.8
Grasses and grasslike plants	1.3	1.1
Mosses	0.5	0.6
Picea abies	0.1	0.2
Pseudostuga menziesii	2.6	2.4
Pteridium aquilinium	1.7	0.5
Sphagnum sp.	1.9	1.3

/continued

Appendix 7 cont'd.

Species	Habitat Type	
	Plantation	
	(E)	(0)
Betula sp.	1.1	0.6
Calluna vulgaris	1.3	2.0
Deschampsia flexuosa	1.2	1.4
Erica tetralix	0.4	0
Grasses and grasslike plants	4.0	6.1
Picea sitchensis	0.9	0.8
Pinus sylvestris	1.3	0.7
Pteridium aquilinium	2.9	2.3
	Rides	
Calluna vulgaris	9.8	11.3
Deschampsia flexuosa	1.5	1.9
Galium saxatile	0.1	0
Grasses and grasslike plants	1.9	1.4
Pteridium aquilinium	6.7	3.7
Vaccinium myrtilus	1.5	0.5

Appendix 8. Age Determination Data

Wear and Layering in the teeth.

All material is from Hamsterley, except Nos. 34 to 40 and No. 75 which came from Croxdale and Netherwitton, and No. 70 from Slaley.

Jaw Number	Month of Death	Estimated Age from Eruption and/or Wear	No. Layers in I_1	No. Layers in M_1	Presumed Actual Age
1	Nov.	$1\frac{1}{2}$	2	2	$2\frac{1}{2}$
2	June	$5\frac{1}{2}$	-	3	$3\frac{1}{2}$
3	"	$1\frac{1}{2}$	1	1	$1\frac{1}{2}$
4	"	$6\frac{1}{2}$	5	5	$5\frac{1}{2}$
5	"	$5\frac{1}{2}$	5	5	$5\frac{1}{2}$
6	"	$6\frac{1}{2}$	5	5	$5\frac{1}{2}$
7	"	7 months	0	0	7 months
8	"	7 months	-	0	7 months
9	"	$8\frac{1}{2}$	-	9	$9\frac{1}{2}$
10	"	$4\frac{1}{2}$	-	3	$3\frac{1}{2}$
11	"	$6\frac{1}{2}$	-	4	$4\frac{1}{2}$
12	Feb.	$1\frac{1}{2}$	1	1	$1\frac{1}{2}$
13	May	1	1	1	1
14	Feb.	$2\frac{1}{2}$	1	1	$1\frac{1}{2}$
15	"	$2\frac{1}{2}$	1	1	$1\frac{1}{2}$
16	Nov.	9	-	8	$8\frac{1}{2}$
17	Dec.	6 months	-	0	6 months
18	May	4	-	4	4
19	May	2	3	3	3
20	"	1	-	1	1
21	"	2	-	2	2
22	"	1	-	1	1
23	"	4	-	3	3
24	"	5	3	3	3
25	"	1	-	1	1
26	"	2	2	0	2
27	"	9	9	9	9
28	"	5	-	3	3
29	"	6	4	4	4
30	"	3	-	3	3
31	"	3	-	2	2
32	"	7	-	5	5

/continued

Appendix 8 cont'd.

Jaw Number	Month of Death	Estimated Age from Eruption and/or Wear	No. Layers in I_1	No. layers in M_1	Presumed Actual Age
33	May	1	1	1	1
34	"	-	-	4	4
35	June	-	-	2	2
36	Aug.	-	-	5	5
37	Sept.	-	-	1	1
38	Oct.	-	-	2	2
39	Nov.	-	-	0	6 months
40	March	-	-	0	9 months
41	May	8	-	8	8
42	June	4	4	4	4
43	May	1	-	1	1
44	July	1	1	1	1
45	Aug.	3	-	2	2
46	Nov.	$2\frac{1}{2}$	2	2	$2\frac{1}{2}$
47	"	5 months	-	0	5 months
48	"	$3\frac{1}{2}$	4	4	$4\frac{1}{2}$
49	"	5 months	0	0	5 months
50	"	$4\frac{1}{2}$	4	4	$4\frac{1}{2}$
51	"	$1\frac{1}{2}$	2	2	$2\frac{1}{2}$
52	"	$1\frac{1}{2}$	2	2	$2\frac{1}{2}$
53	"	$3\frac{1}{2}$	3	3	$3\frac{1}{2}$
54	"	$4\frac{1}{2}$	4	4	$4\frac{1}{2}$
55	"	$5\frac{1}{2}$	5	5	$5\frac{1}{2}$
56	"	$3\frac{1}{2}$	4	4	$4\frac{1}{2}$
57	"	$2\frac{1}{2}$	3	3	$3\frac{1}{2}$
58	"	$1\frac{1}{2}$	2	2	$2\frac{1}{2}$
59	"	5 months	-	0	5 months
60	"	$3\frac{1}{2}$	-	2	$2\frac{1}{2}$
61	"	5 months	-	0	5 months
62	"	$2\frac{1}{2}$	-	2	$2\frac{1}{2}$
63	"	$6\frac{1}{2}$	-	5	$5\frac{1}{2}$
64	"	$6\frac{1}{2}$	5	5	$5\frac{1}{2}$
65	"	$2\frac{1}{2}$	3	3	$3\frac{1}{2}$
66	"	$2\frac{1}{2}$	-	2	$2\frac{1}{2}$
67	"	$2\frac{1}{2}$	1	1	$1\frac{1}{2}$
68	"	$1\frac{1}{2}$	1	1	$1\frac{1}{2}$

/continued

Appendix 8 cont'd.

Jaw Number	Month of Death	Estimated Age from Eruption and/or Wear	No. Layers in I_1	No. Layers in M_1	Presumed Actual Age
69	May	1	-	1	1
70	Dec.	$8\frac{1}{2}$	9	9	$9\frac{1}{2}$
71	May	2	-	2	2
72	Dec.	$3\frac{1}{2}$	-	3	$3\frac{1}{2}$
73	Dec.	6 months	-	0	6 months
74	Dec.	6 months	-	0	6 months
75	April	-	5	5	5
76	May	1	-	0	1
77	"	1	-	1	1
78	"	2	2	2	2
79	"	1	-	1	1
80	"	2	3	3	3
81	"	5	5	5	5
82	"	2	2	2	2
83	"	1	-	0	1
84	"	1	1	0	1
85	"	1	1	0	1
86	"	7	6	6	6
87	"	4	3	3	3
88	"	1	-	0	1
89	"	1	-	0	1
90	"	1	-	1	1
91	"	1	-	1	1
92	"	1	-	1	1
93	"	2	2	2	2
94	"	1	-	1	1
95	"	1	1	1	1
96	"	3	4	4	4
97	"	2	-	2	2
98	"	4	4	4	4
99	"	1	1	0	1
100	"	1	1	1	1
101	"	2	2	2	2
102	"	1	1	1	1
103	"	4	4	4	4

/continued

Appendix 8 cont'd.

Jaw Number	Month of Death	Estimated Age from Eruption and/or Wear	No. Layers in I_1	No. Layers in M_1	Presumed Actual Age
104	May	2	2	2	2
105	"	2	2	2	2
112	"	6	6	6	6
113	"	2	2	0	2
114	"	4	4	4	4
115	"	2	2	0	2
116	"	4	4	4	4
117	June	8	9	9	9
118	July	8	-	8	8
119	"	4	-	3	3
125	June	2	-	2	2

Appendix 8 cont'd.

Heights of Cusps of M_1.

Age	Jaw No.	Height of M_1 Buccal cusps in mms.	Mean (in mms.)	Sex
	17	7.0, 6.5, 5.5, 6.5	6.4	
	47	6.5, 7.5, 6.0, 7.0	6.7	
	49	6.5, 5.5, 5.0, 6.5	5.8	
	59	7.0, 5.0, 7.0, 5.0	6.0	
5 to 7 months	61	7.5, 7.5, 7.5, 7.5	7.5	Female
	73	7.0, 7.0, 7.5, 7.0	7.1	
	74	7.0, 5.5, 7.0, 7.0	6.6	
	7	7.0, 7.5, 7.0, 7.0	7.1	
	8	7.0, 7.0, 7.0, 6.5	6.9	
	13	7.5, 7.5, 7.0, 7.0	7.2	
	20	6.0, 6.0, 6.0, 6.0	6.0	
	22	6.0, 6.0, 6.0, 6.0	6.0	
	25	7.0, 7.0, 7.0, 7.0	7.0	
	33	6.5, 7.0, 7.0, 7.0	6.9	
	43	8.0, 6.5, 7.0, 7.0	7.1	
	44	7.0, 7.0, 7.0, 7.0	7.0	
	76	7.0, 6.0, 6.5, 7.0	6.6	
	77	7.0, 7.0, 7.0, 7.0	7.0	
	79	7.0, 7.5, 7.5, 7.0	7.2	
	83	7.0, 7.0, 7.5, 6.5	7.0	
	84	8.0, 7.5, 7.0, 8.0	7.6	
1 year	85	6.5, 6.5, 6.5, 6.0	6.4	Male
	88	8.0, 7.0, 6.5, 7.0	7.1	
	89	5.0, 5.5, 6.0, 7.0	5.9	
	90	6.0, 6.0, 6.0, 6.0	6.9	
	91	7.5, 7.0, 7.0, 8.0	7.4	
	92	7.0, 6.5, 7.0, 7.0	6.9	
	94	6.5, 6.0, 6.5, 7.0	6.5	
	95	7.5, 7.0, 7.0, 6.5	7.0	
	99	4.5, 6.0, 5.5, 5.5	6.0	
	100	6.0, 6.0, 5.5, 5.5	5.7	
	102	7.0, 7.0, 7.0, 7.5	7.1	

Appendix 8 cont'd.

Age	Jaw No.	Height of M_1 Buccal Cusps in mms.	Mean (in mms.)	Sex
	12	6.5, 6.5, 7.0, 7.0	6.7	
	14	6.0, 6.5, 6.0, 6.0	6.1	
1½ years	15	6.5, 6.5, 7.0, 7.0	6.7	Female
	67	5.5, 5.0, 5.5, 5.5	5.4	
	68	7.5, 7.5, 7.5, 7.5	7.5	
	3	6.0, 7.0, 6.0, 6.5	6.4	
	21	6.5, 6.0, 5.0, 5.0	5.6	
	26	5.0, 6.0, 6.0, 6.0	5.7	
	31	6.0, 6.0, 6.0, 6.0	6.0	
	45	5.0, 5.5, 5.0, 5.5	5.2	
	78	7.0, 7.0, 8.0, 8.0	7.5	
	82	5.5, 6.0, 5.5, 5.5	5.6	
	93	6.5, 6.0, 6.0, 7.0	6.4	
2 years	97	7.5, 7.0, 7.0, 7.5	7.2	Male
	101	6.5, 6.5, 7.0, 7.0	6.7	
	104	6.0, 6.0, 7.0, 7.0	6.5	
	105	5.5, 5.5, 5.5, 5.0	5.4	
	113	6.5, 6.5, 6.0, 6.5	6.4	
	115	5.5, 6.5, 6.0, 6.0	5.7	
	125	6.5, 7.5, 6.5, 6.0	6.6	
	1	6.0, 6.0, 6.0, 6.0	6.0	
	46	6.0, 5.5, 5.0, 6.0	5.6	
	51	6.5, 6.5, 6.0, 6.0	6.2	
2½ years	52	6.0, 6.0, 6.0, 6.0	6.0	Female
	58	5.5, 5.5, 6.5, 5.5	5.7	
	60	5.5, 5.0, 5.0, 5.5	5.2	
	62	5.5, 5.5, 5.0, 5.5	5.4	
	66	6.5, 6.5, 6.5, 6.0	6.4	
	19	5.5, 5.0, 5.0, 5.0	5.0	
	23	5.0, 5.0, 4.0, 4.0	4.5	
	24	4.5, 4.5, 5.0, 4.5	4.6	
3 years	28	4.5, 4.0, 3.0, 3.5	3.7	Male
	30	5.5, 5.5, 5.0, 5.5	5.4	
	80	5.5, 6.0, 6.5, 6.0	6.0	
	119	5.0, 5.5, 5.5, 5.0	5.2	
	87	5.0, 5.0, 5.0, 5.0	5.0	

Appendix 8 cont'd.

Age	Jaw No.	Height of M_1 Buccal Cusps in mms.	Mean (in mms.)	Sex
	2	2.5, 3.0, 3.0, 3.0	2.9	
	10	5.0, 4.5, 5.0, 5.0	4.9	
	53	5.0, 5.0, 5.0, 4.5	4.9	
3½ years	57	5.5, 5.0, 6.0, 6.5	5.7	Female
	65	4.5, 4.5, 4.5, 4.5	4.5	
	72	5.0, 5.5, 4.5, 5.5	5.1	
	18	4.0, 3.5, 4.0, 3.5	3.7	
	29	3.5, 3.5, 4.0, 3.5	3.6	
	42	3.5, 3.0, 4.0, 4.0	3.6	
4 years	96	5.0, 5.0, 5.0, 5.0	5.0	Male
	98	5.0, 4.0, 4.0, 5.0	4.5	
	103	5.0, 5.0, 4.5, 5.0	4.9	
	114	4.0, 5.0, 4.5, 5.0	4.6	
	116	4.5, 4.5, 4.5, 5.0	4.6	
	11	2.5, 3.5, 3.0, 3.0	3.0	
	48	4.5, 4.5, 4.0, 4.5	4.4	
4½ years	50	3.5, 3.5, 4.0, 4.0	3.7	Female
	54	4.0, 4.0, 4.0, 4.0	4.0	
	56	4.0, 4.0, 4.5, 4.5	4.2	
	32	1.5, 2.5, 3.0, 3.0	2.5	
5 years	81	3.5, 4.0, 4.0, 4.0	3.9	Male
	4	1.5, 1.5, 1.5, 1.5	1.5	
	6	3.5, 3.5, 4.0, 4.5	3.9	
	63	4.0, 3.0, 3.5, 3.5	3.5	
5½ years	64	3.0, 2.5, 3.0, 2.5	2.7	Female
	55	3.0, 2.5, 3.5, 3.5	3.1	
	5	5.0, 4.0, 4.0, 4.0	4.2	
	112	3.0, 3.5, 3.5, 3.5	3.4	
6 years	86	3.0, 2.0, 1.5, 2.0		Male

Appendix 8 cont'd.

Age	Jaw No.	Height of M_1 Buccal Cusps in mms.	Mean (in mms.)	Sex
8 years	41	0, 2.5, 2.0, 2.0	1.6	Male
	118	2.5, 1.5, 2.5, 2.0	2.1	
8½ years	16	1.0, 2.5, 2.5, 2.0	2.0	Female
9 years	27	1.0, 1.0, 2.0, 1.5	1.4	Male
	117	2.5, 2.5, 2.0, 2.5	2.4	
9½ years	70	1.0, 2.5, 2.5, 1.5	1.9	Female
	9	2.0, 1.5, 1.0, 1.0	1.4	

Appendix 8 cont'd.

Weight of Eye lens and of Body

Age	Deer No.	Lens Weight in mg. Right	Left	Body Weight in Kg. Whole	Gralloched
6 months	49	130.7	129.9	13.4	9.1
	59	141.8	141.1	13.6	8.8
	61	167.5	166.7	16.0	11.2
	47	124.0	123.0	14.2	10.2
1 year	76	233.5	238.2	19.0	14.0
	77	212.0	213.4	18.0	13.5
	79	225.8	225.5	22.0	15.0
	83	211.4	214.4	20.0	13.8
	84	-	-	18.0	13.0
	85	214.0	214.6	21.0	13.8
	88	204.0	203.7	14.0	9.5
	89	205.9	202.4	16.5	11.5
	90	205.0	189.5	15.0	10.5
	91	208.7	209.4	19.5	13.5
	92	228.7	234.6	16.0	10.5
	94	-	-	16.5	11.0
	95	215.8	206.3	15.0	10.0
	99	247.2	253.4	-	-
	107	205.0	204.4	-	-
	108	213.4	208.4	-	-
	109	201.5	205.6	-	-
	110	227.5	221.6	-	-
	111	224.6	225.0	-	-
1½ years	67	316.3	316.1	24.6	18.2
	68	248.0	247.9	24.4	16.2
2 years	78	-	-	22.0	16.0
	82	261.0	259.6	22.5	15.5
	93	-	-	19.5	13.0
	97	255.0	251.4	19.0	13.5
	101	313.0	318.6	25.5	18.5
	104	-	-	22.5	16.5
	105	-	-	28.0	21.0
	113	270.7	270.8	-	-
	115	269.3	271.2	-	-
	125	260.8	259.8	-	-
2½ years	66	309.3	310.3	25.5	16.3
	58	298.9	297.3	27.4	18.0
	62	320.0	320.5	25.0	17.4
	60	301.6	305.7	23.6	16.0
	52	228.4	227.9	-	-
	46	261.0	260.8	27.2	19.2
3 years	80	283.3	278.3	24.0	16.5
	87	273.3	278.6	18.5	13.5
	119	311.1	310.1	24.0	16.0

/continued

Appendix 8 cont'd.

Age	Deer No.	Lens Weight in mg. Right	Left	Body Weight in Kg. Whole	Gralloched
$3\frac{1}{2}$ years	50	350.5	351.0	26.0	17.7
	65	280.5	281.4	20.6	15.4
	53	244.7	244.0	-	-
	72	311.8	313.4	23.7	13.8
	57	280.0	287.0	23.0	15.4
4 years	96	355.8	347.7	20.0	14.0
	98	275.7	269.1	13.5	9.5
	103	-	-	14.0	9.5
	116	289.0	283.5	-	-
$4\frac{1}{2}$ years	48	301.0	300.7	26.4	17.1
	54	336.9	337.8	24.4	17.6
	56	294.6	287.0	24.6	16.0
	50	-	-	26.0	17.7
5 years	81	338.1	342.1	20.0	15.0
$5\frac{1}{2}$ years	63	343.4	347.5	22.2	13.6
	55	340.7	342.1	-	-
	64	-	-	25.0	16.0
6 years	112	374.2	376.4	-	-
	86	366.6	363.1	28.0	21.0
8 years	118	340.6	360.5	24.5	17.0
$9\frac{1}{2}$ years	20	345.9	350.7	-	-

Gralloched Weight = Whole body weight minus the oesophagus, windpipe, thoracic and abdominal viscera.

Appendix 9. Percentage monthly distribution of observations among habitat types.[1]

Month	Total Observations / Total Hours	Mature Spruce %[2]	Mature Pine %	Deciduous %	Plantation %	Clearings %	Rides %
1973							
Jan.	69/32	15.9	2.9	1.4	8.7	53.6	17.4
Feb.	65/195	29.2	0	7.7	4.6	52.3	6.1
March	130/56	23.1	3.1	7.7	7.7	53.8	4.6
April	103/68	27.2	1.9	7.8	4.8	56.3	1.9
May	119/69.5	24.4	2.5	5.0	10.9	46.2	10.9
June	183/98.5	25.1	2.2	9.3	11.5	47.5	4.4
July	111/49.5	27.9	2.7	1.8	6.3	58.5	2.7
Aug.	76/23	18.4	5.3	2.6	5.3	64.5	3.9
Sept.	100/43	15.0	2.0	2.0	4.0	68.0	9.0
Oct.	127/33	7.9	3.9	2.4	7.1	75.6	3.1
Nov.	58/43	18.9	3.4	6.9	5.2	56.9	8.6
Dec.	52/50	23.1	15.4	3.8	5.8	46.1	5.8
1974							
April	175/54	7.4	1.1	1.7	11.4	74.3	4.0
May	111/51	13.5	0.9	9.9	11.7	61.3	2.7
June	98/50	13.3	5.1	6.1	17.3	55.1	3.1
July	75/30.5	9.3	1.3	6.7	10.7	69.3	2.7

1. Deer were never observed in the fields at any time

2. Percentage of deer observed per habitat type.